FEBRUARY 1956

Product Engineering

THE McGRAW-HILL MAGAZINE OF DESIGN ENGINEERING

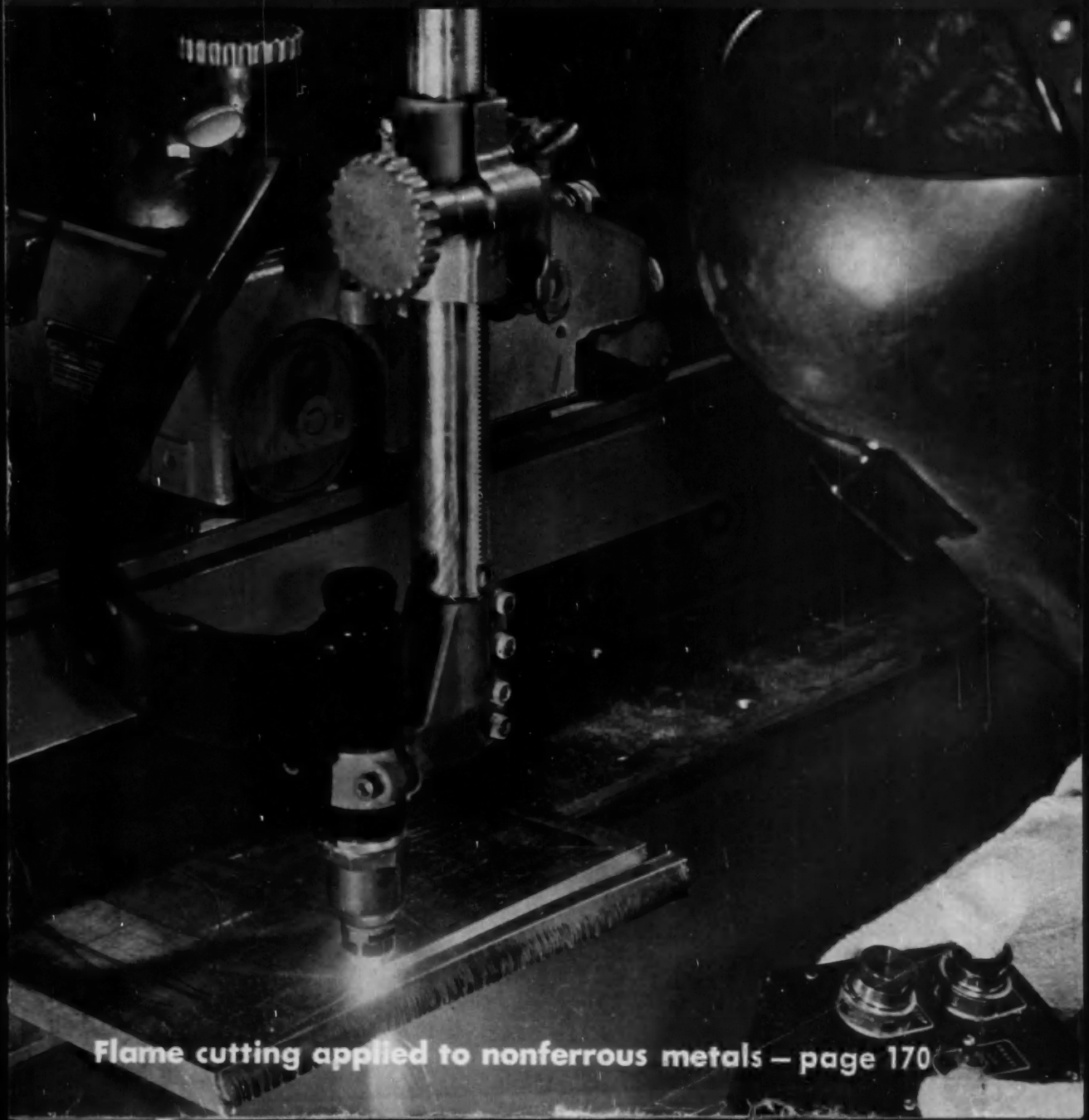
FIVE DOLLARS A YEAR

Starting Methods for Three-Phase Motors

Solid-Film Lubricants

Forming Titanium

High Pressure Seals



Flame cutting applied to nonferrous metals – page 170

C/R SEAL BACKS UP EXTRA BRAKING POWER

Every time you touch your brake pedal it must function dependably. In a well-known power brake unit a small back-up seal is doing a big job—providing an extra margin of safety. It's a C/R Oil Seal used between the vacuum and hydraulic cylinders. The sealing element had to be designed to exacting requirements. It seals effectively on both sides, withstands pressures to 10 psi, and provides maximum flexibility to follow possible eccentricity up to .025". In thousands of applications there has never been a failure.

If your product must conform to equally high standards of performance, consider C/R Oil Seals. You may choose from 17 stock types in over 1800 sizes, or work with C/R engineers on special designs. Write for detailed information.

More automobiles, farm and industrial machines rely on C/R Oil Seals than on any similar sealing device.

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Export Sales: Geon International Corp., Great Neck, New York

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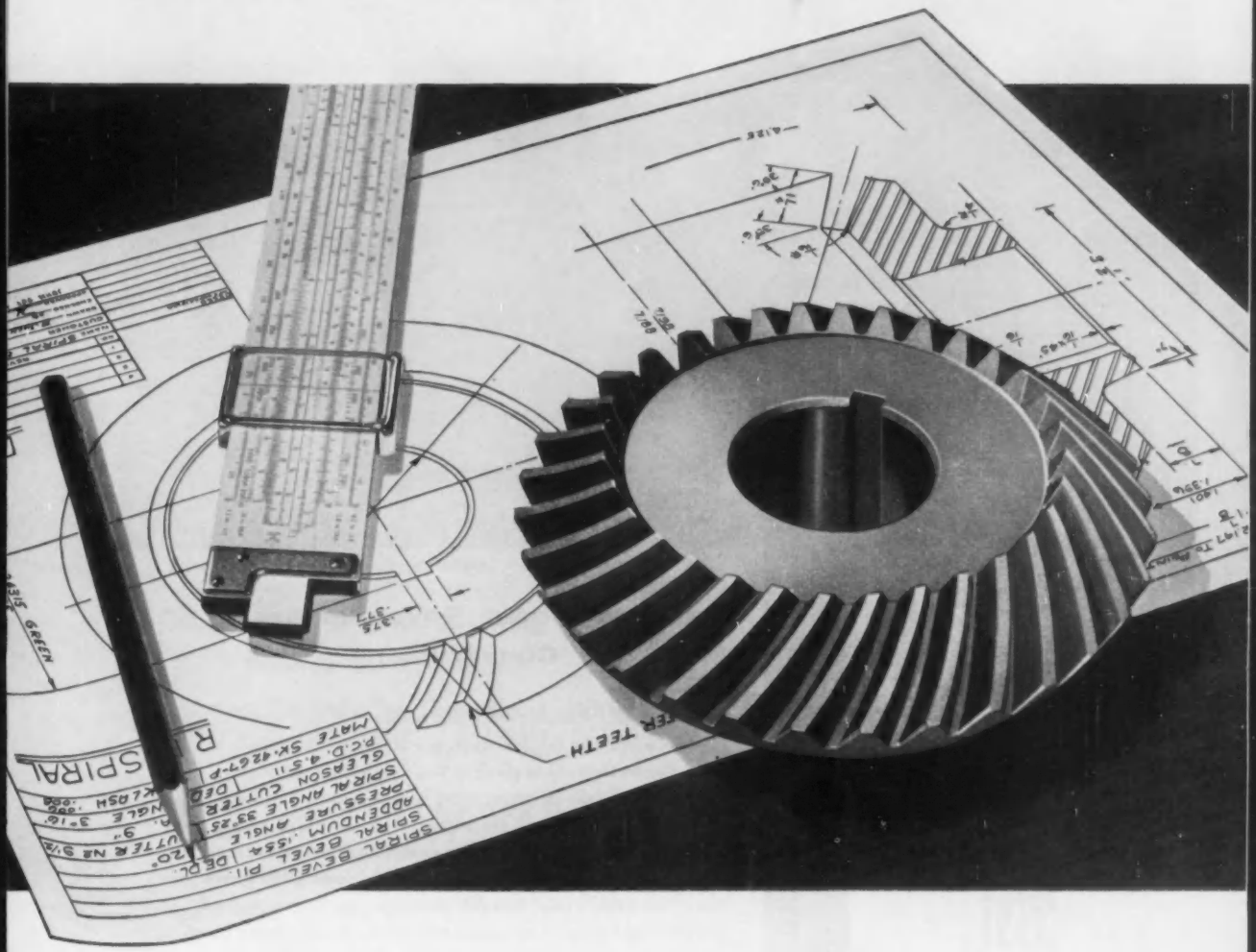
Sirvene (synthetic rubber) molded pliable parts • Sirvis-Conpor mechanical leather cups, packings, boots • C/R Non-metallic Gears

"ENGINEERED QUOTATIONS"

When our engineers study our customers' prints, they look for ways to improve gear performance, ways to simplify gear installations, ways to cut gear costs. When they find a way that they consider better they report it to the customer for his consideration. Very often these "engineered quotations" are accepted. Such careful scrutiny of every engineering and manufacturing step by *gear specialists* is one reason why so many manufacturers use Automotive Gear Works as their "gear department". May we submit an "engineered quotation" on your gear requirements?



DOUBLE DIAMOND GEARS

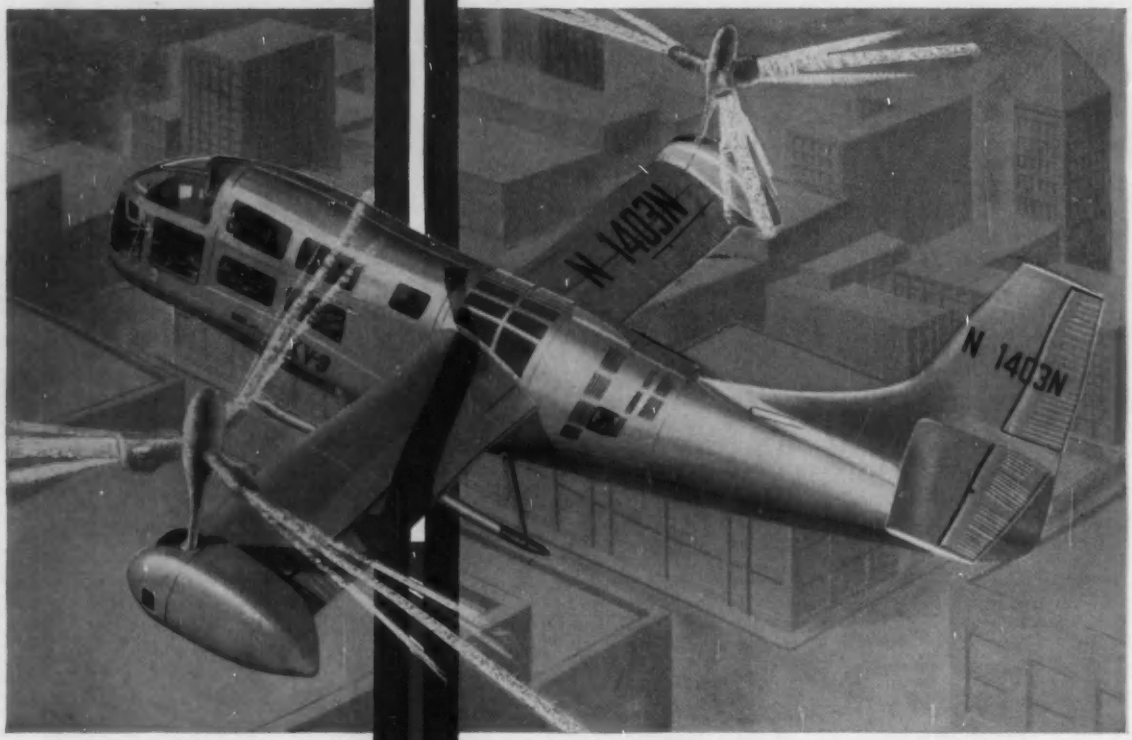
FOR AUTOMOTIVE, FARM EQUIPMENT AND GENERAL INDUSTRIAL APPLICATIONS
GEAR-MAKERS TO LEADING MANUFACTURERS

Automotive Gear Works, inc.

ESTABLISHED IN 1914

RICHMOND, INDIANA

COOL COMMUTER!



Harrison Cools Revolutionary New Bell Convertiplane

Take off from the back yard! Land on the roof top! And waste no time between! The revolutionary new Bell Convertiplane is a helicopter at the field, a plane in the sky. This means highly variable conditions for engine temperature control. Harrison engineering came up with the answer, with controlled cooling that equalizes the variables, maintains correct engine temperatures under all flight conditions. Design of special cooling equipment for one of the world's most versatile aircraft is another example of Harrison leadership in temperature control. Let Harrison's broad experience and extensive research facilities help you. Whenever you have a temperature-control problem, look to Harrison for the answer.

GM GENERAL MOTORS

Temperature control is our business at Harrison. Harrison heat exchangers are known the world over for efficiency and reliability And Harrison keeps pace with new needs with the most intensive temperature-control research in the industry.

TEMPERATURES MADE TO ORDER

HARRISON

RADIATOR DIVISION, GENERAL MOTORS CORP., LOCKPORT, N.Y.

Product Engineering

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German Standards Bureau ..... Richard Vieweg 158
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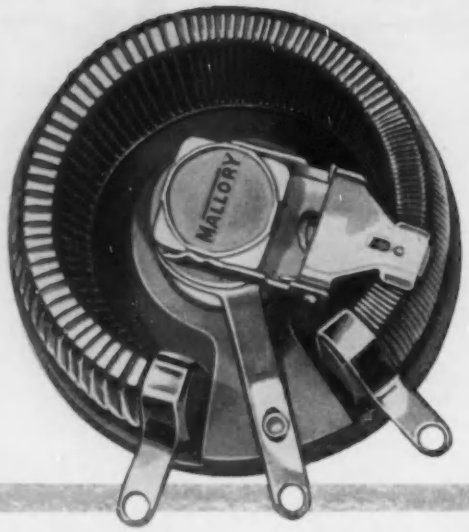
MALLORY



Contact troubles are prevented by the exclusive Mallory hinged contact arm, which always maintains correct pressure, allows easy brush cleaning.

Mallory Power Rheostats

Give Extra Performance . . . *Without Extra Cost*

Mallory
Wire Wound Resistors
for heavy duty service

A comprehensive line of vitreous enamel power resistors made by Mallory meets the requirements of many electrical and electronic circuits where high power dissipation is needed . . . in voltage dividers, bleeders, load or shunt resistors.

Mallory resistors are space-wound on high quality steatite cores, using large gage wire with matched temperature coefficients of all parts. They are designed for maximum heat dissipating area, to assure cool operation. A special non-porous, non-alkaline vitreous enamel coating gives effective protection of the winding.

Fixed and adjustable types are available in ratings from 5 to 200 watts. Write for data.

Famous for long service, Mallory power rheostats offer you many unique features of design that assure trouble-free operation, and economical cost.

The hinged contact arm eliminates variation in brush pressure that can cause overheating or failure. The spring carries no current . . . cannot soften when overloads occur. You can lift the brush for cleaning, and the spring snaps it back to correct pressure.

You can depend on Mallory rheostats for cool operation. They are designed with ample ventilation, and conservatively rated. Depend on them for stability, too . . . obtained through the use of high grade ceramic insulation, and tough, impervious vitreous enamel protective coating on the winding. Depend on them for accurate linearity . . . the result of Mallory precision winding methods.

Most tapered windings can be produced with a single size of wire, by means of special Mallory variable pitch winding techniques. This method of construction eliminates joints, hot spots and points of excessive wear . . . reduces rheostat cost.

Standard Mallory rheostats cover the complete range from 25 to 500 watts. For your special requirements, our engineers can design single or multiple units to fit your application. Write today for our latest Technical Bulletin.

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Serving Industry with These Products:
Electromechanical—Resistors • Switches • Television Tuners • Vibrators
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Parts distributors in all major cities stock Mallory standard components for your convenience.

P. R. MALLORY & CO. Inc.
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P. R. MALLORY & CO., Inc., INDIANAPOLIS 6, INDIANA

THIS MONTH'S COVER

New to the nonferrous metal field is the Heliarc high-speed flame cutter, capable of cutting ¼ in. aluminum sheet at speeds up to 300 in. per min and 1 in. aluminum at 50 in. per minute. Process has same circuit used in Heliarc welding with an argon-hydrogen shielding gas.

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Developments

To Watch

UNAFFECTED BY SEVERE TEMPERATURE CHANGE . . .

. . . . a new metal is reported to have a constant modulus of elasticity from −90 to +240 F. The metal, a nickel-chromium-iron-titanium alloy called Ni-Span C is made by the International Nickel Co., and processed by the H. A. Wilson Co., of Union, N. J. By a precipitation hardening heat treatment, it can be given higher hardness and mechanical properties than are available in other constant modulus alloys even with cold working. Also, by a variation in the heat treatment, the thermoelastic coefficient can be adjusted. Thus, any batch can be "set" to order so that in response to a given temperature change it becomes stiffer, less stiff, or remains elastically uniform. This characteristic can be used to build into any instrument a temperature compensation factor. The metal is used in the new automatic parachute release mechanism which senses the altitude and waits until the pilot falls out of the upper atmosphere before pulling the ripcord. This device consists of three small diaphragms made of the new metal, which are sensitive to air pressure, but not affected by the temperature change. Other applications are: torque indicators, time fuses, radar pressurization switches, watch hair springs, pressure gages, and scales. Ni-Span C can be rolled or forged either hot or cold, or formed by blanking, piercing, bending, or drawing. It can be soft soldered, silver soldered, or welded, and is available in wire, strip, tubing, forgings, or fabricated parts.

CHEMICAL MILLING OF MAGNESIUM . . .

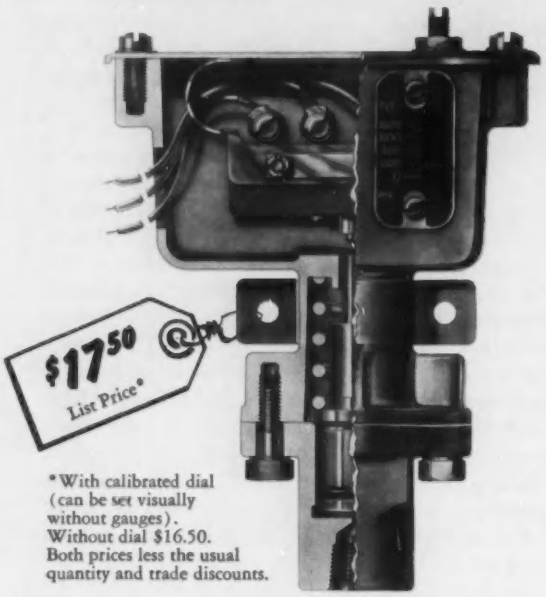
. . . . a process up to now used primarily for aluminum aircraft parts is being investigated by the Dow Chemical Co., of Midland, Mich., and the Turco Products Co., of Los Angeles, Calif. The process is claimed to be faster and more flexible than conventional milling methods, and the equipment less costly. To date, one etching solution, said to be highly efficient, has been developed for magnesium milling. Additional work is required to perfect the etchant, and improving control procedures and masking techniques. Tolerances of ±0.003 in. with the chemical milling process are possible in assembly line operations. Acid etchants for steel and titanium alloys are now being developed.

HIGH TEMPERATURE STRAIN GAGE MATERIAL . . .

. . . . for use at temperatures up to 2200 F is being tested at the Armour Research Foundation of the Illinois Institute of Technology, Chicago 16, Ill. The special alloy is oxidation resistant at this high temperature; has sufficient formability; and does not show electrical instability as a result of temperature. The material will withstand a change from room temperature to 2200 F with a resistance change of less than 5 per cent.

(continued on page 7)

If you build PRODUCTION EQUIPMENT compare this pressure switch for RUGGEDNESS, DEPENDABILITY and COST



*With calibrated dial (can be set visually without gauges). Without dial $16.50. Both prices less the usual quantity and trade discounts.

WE BUILD IN	WE DON'T USE
RUGGEDNESS Can take surges— (High proof pressures) Continuous operation— (Millions of cycles) No sticking— (in dirty fluid)	 **LINKAGES & BEARINGS** Which wear quickly—(cause settings to drift and switch to fail).
LABOR & MATERIAL SAVINGS No return drain piping— (Sealed piston) Mounts where convenient (Operates in any position, Not sensitive to vibration)	 **UNSEALED PISTONS** Which add to your installation cost (return piping). Are critical to dirt— (pistons get stuck).

BARKSDALE VALVES

PRESSURE SWITCH DIVISION

5125 Alcoa Avenue, Los Angeles 58, California

Ask for bulletins 9612 and C9612.

ARE YOU CHANGING DESIGN ON AIR OPERATED MACHINES TO CUT COST AND IMPROVE OPERATION?

*$18.50 is the list price for the ¼ inch port size and $19.50 for the ⅜ inch, less the usual quantity and trade discounts.

HERE'S BOTH LOWER COST AND BETTER CONTROL IN THE 'SHEAR-SEAL' 4-WAY AIR VALVE

You need no oiler and filter ahead of this valve because it's made entirely of corrosion resistant materials and moisture won't harm it.

It operates freely on dry, unlubricated air, and dirt or pipe scale in the line cannot damage the valve or hold it open because of the unique "Shear-Seal" design.

The leak-proof holding quality which does not diminish after prolonged service is perhaps the most outstanding characteristic of the wear-compensating "Shear-Seal."

The external design stresses savings through convenience of porting, any port can be the "in" port; of mounting, valve has a bracket that may be shifted or removed to make way for panel mounting; of maintenance, valve can be serviced without touching the plumbing.

Ask for bulletin A-5.

BARKSDALE VALVES

5125 Alcoa Avenue, Los Angeles 58, California

Developments to Watch

HEAVY-DUTY HYDRAULIC PISTONS . . . .

. . . . usually heavy pieces of equipment, are being made lighter. The reason is a new material made of a thermosetting phenolic laminate bonded to a base of 24ST4 aluminum. The new piston was designed by the Cleveland Pneumatic Tool Co. for its Aerol type shock-absorbing strut used in the landing gears of commercial and military planes. The plastic-clad material was developed by the Synthane Corp., of Oaks, Pa. The plastic covering on the 38 in. long aluminum tube is a continuous length of specially treated fine-weave cotton fabric impregnated with a phenolic resin, and wrapped around the tube. After oven curing, the laminate wrapper is machined to the proper dimension. Piston sizes range from 3 to 10 in. Feature of the clad-piston is its ability to prevent seizing of the piston and resist scoring. Other advantages are its high strength- to-weight ratio, and ability to resist the action of the hydraulic fluid.

ORGANIC COATINGS FOR HOT-WATER TANKS . . . .

. . . . are being evaluated at the Battelle Memorial Institute with an eye towards increasing the life and decreasing the cost of these structures already protected cathodically. Besides the presence of alkali and hydrogen formed at the cathodic surface, this coating would be subjected to an accelerated penetration by the water moving under the influence of 0.6-0.8 volt developed between the magnesium and iron. The chief requirements of organic coatings in this use are alkali resistance and water impermeability. Coatings based on epoxy-phenolic resin combinations seem to show promise as a coating in cathodically protected tanks subjected to temperatures up to 180 F or higher. The epoxy-phenolic coatings will perform satisfactorily with cathodic protection in areas with waters of high electrical resistance and where protective densities will be low. Work is being done on coating systems where current densities will be high. The objective of such work is the elimination of coating blistering.

JOINING HIGH STRENGTH STEELS . . . .

. . . . by a method of diffusion bonding has been found to be so effective that it has the strength of the original steel. Developed at the Armour Research Foundation of the Illinois Institute of Technology, Chicago 16, Ill., the new method is essentially a brazing process in which the filler metal diffuses into the parent metal, leaving no discrete joint. According to test reports, bars of 4340 grade have been butt-joined by this method and then heat treated to a tensile strength of 182,000 psi.

A NEW PROCESS FOR COATING METALS, CERAMICS, GLASS . . . .

. . . . and wood with various types of plastic materials has been licensed exclusively in this country by Polymer Corp., Reading, Pa. Developed in Germany under the name of whirlsintering, it will be known as the Whirlclad process in this country. The process is said to permit the use of coating materials which have never been applied satisfactorily. Preliminary experience has been with nylon and low pressure polyethylene as the coating mediums, but other materials like polystyrene, cellulose acetate, butyrate, acrylics and epoxy resins can be used. The process consists essentially of dipping preheated parts into a container of fluidized plastic material in a finely divided solid form. Much heavier coatings

(Continued on page 9)

When you've got your eye on the one who will buy, *you use Bonderite under the paint*

PROTECTED BY Bonderite QUALITY CORROSION RESISTANT

BUY-SIGN for people looking for lasting finish...

Bonderite seals, furnished free to Bonderite users, promise "This product will look better longer." Six million will be used this year. Write for information on Bonderite seals for *your* product.

● There are lots of reasons for preferring Parker's corrosion resistant paint base, Bonderite: dependability, over-all economy, quality of product, results and service.

There's another advantage that's *exclusively* Bonderite's: Only Bonderite is known to *your* customer, the ultimate consumer. A quarter of a century of national advertising has established a cause-and-effect relationship between Bonderite-protection and a product that looks better longer.

Yes, when you've got your eye on the one who will buy, you use Bonderite under the paint—and use it to help you make sales.

******Bonderite, Bonderlube, Parco, Parco Lubrite, Parker Pre-Namel—Reg. U. S. Pat. Off.*

PARKER RUST PROOF COMPANY
2179 E. MILWAUKEE, DETROIT 11, MICHIGAN

Since 1915—leader in the field

BONDERITE	BONDERITE and BONDERLUBE	PARCO COMPOUND	PARCO LUBRITE	TROPICAL
corrosion resistant paint base	aids in cold forming of metals	rust resistant	wear resistant for friction surfaces	heavy duty maintenance paints since 1883

can be achieved with a single dip than with solvent coating methods. The process is said to produce uniform coatings on any irregular shaped object and pipe interiors, and since the coating materials are not applied in combination with plasticizers or extenders, there is no chance of these agents affecting the chemical or mechanical performance of the coated surface. Coating thicknesses for nylon have ranged from 0.008 to 0.020 in., and for polyethylene, 0.010 to 0.040 in. Parts up to 37 in. x 37 in. x 76 in. can be handled.

ALL ACCESSORIES ARE PNEUMATICALLY DRIVEN . . . .

. . . . on Boeing's new B-52 Stratofortress, and is the first time in history that an aircraft system is so operated. Producers of the equipment are the General Electric Co. Aircraft Accessory Dept., in Lynn, Mass. Hydraulic pumps and alternators are driven by air turbines getting their power from the jet engine compressor. Each unit consists of turbine, reduction gears, and controls. Each unit can be installed in remote locations close to the power need. For hydraulic power, a high-speed turbine with throttling control drives a 3,000 psi variable displacement hydraulic pump through double reduction gearing. Drives are also provided for the lube oil and scavenging pumps and a fan for the oil cooler. The governor is a simple flyball mechanism operating through a hydraulic servo to control the air flow to the turbine.

HAFNIUM NOW PRODUCED IN SOFT, DUCTILE FORM . . . .

. . . . by an iodide process similar to that used for the recovery of zirconium. In fact, hafnium is a by-product of zirconium production, and as such it can be produced for approximately $75 per lb as against $275-300 if it were produced separately. Hafnium is used widely in the atomic energy field as a control device in nuclear reactors. A double arc melting process is used to consolidate the iodide crystals into a form which can be fabricated. In a newer process, ductile hafnium can be produced directly from the iodide crystals by a consumable electrode made of iodide crystal hafnium bars. Hafnium is hot worked, and is forged at 2000 F with single blow reductions of 45 per cent. Heated to 1700 F a slab can be hot rolled. Heated to 1800 F it can be drawn into wire. The process was developed at Westinghouse Electric Corp., Atomic Power Div., East Pittsburgh, Pa.

AND IN ADDITION . . . .

. . . . According to reports, the first atomic airplane engine has been built and the first ground tests have been run; design and construction was at General Electric's Evandale, Ohio plant . . . . Although automobile production for January was at a record pace, the steel companies supplying the auto plants in Detroit say that there will be a cut of 13 per cent for the second calendar quarter of this year . . . . Trials have been completed recently on a British electric train using a germanium rectifier. The air-cooled 750 kw rectifier unit converts a-c from the overhead wire to d-c for the driving motors . . . . The plastics industry had another record year in 1955 when it produced 3.6-billion pounds of raw materials, a 30 per cent increase over 1954, and 400 per cent since World War II . . . . A transistorized pocket-size "pager" can eliminate the noise of bells and gongs in factory public address systems. Weighing 10 oz., the device has a buzzer to notify the wearer, and will transmit a voice message. The system is selective, and up to 264 individual units can be operated from one switchboard. Motorola, Inc. is the manufacturer.

Armco 17-7 PH Stainless Rates Tops at 300-800 F on

STRENGTH-WEIGHT BASIS

Guided Missile pressure-booster tank of Armco 17-7 PH is tested at 3500 psi pressure—a calculated average stress of 169,000 psi. This metal also is used for fuel tanks, to contain red or white fuming nitric acids and other oxidizers.

On a *strength-weight* basis, Armco 17-7 PH Stainless Steel is unexcelled for service at temperatures of 300 to 800 degrees F. In this temperature range, Armco 17-7 PH has these pound-for-pound characteristics in comparison with the best ferrous and non-ferrous metals:

- *UNSURPASSED SHORT-TIME TENSILE STRENGTH*
- *SUPERIOR SHORT-TIME YIELD STRENGTH*
- *HIGHER STRESS-TO-RUPTURE STRENGTH*
- *HIGHER CREEP STRENGTH*

Yet Armco 17-7 PH is not a costly metal. It is well within the stainless steel price range. Besides having fine corrosion resistance, it is readily fabricated and welded in the soft condition—draws and forms much like 18-8 stainless steel. After fabrication, it takes only a low-temperature double heat treatment at 1400 F plus 1050 F to develop its high mechanical properties.

Armco 17-7 PH is supplied in sheets, strip, plates, bars, angles and wire.

For complete data, just fill out and mail the coupon.

Armco Steel Corporation, 1525 Curtis Street, Middletown, Ohio
Tell me why Armco 17-7 PH is unexcelled on a strength-weight basis for service at 300 to 800 degrees F.

Name:_____

Firm:_____

Street:_____

City:_____ Zone:_____ State:_____

ARMCO STEEL CORPORATION 1525 CURTIS ST., MIDDLETOWN, OHIO

SPECIAL STEELS

SHEFFIELD STEEL DIVISION • ARMCO DRAINAGE & METAL PRODUCTS, INC. • THE ARMCO INTERNATIONAL CORPORATION

CLOSE CONTROL AT A COMPETITIVE PRICE

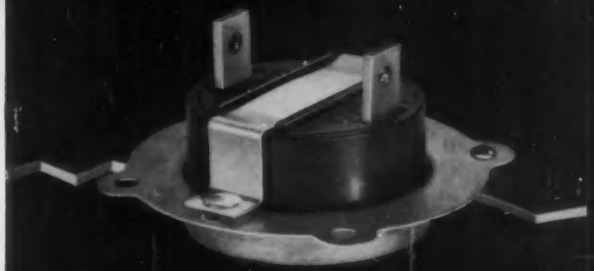
for warm-air
and household heating applications
new **STEMCO**

TYPE D THERMOSTATS

New Stemco Type D Thermostats give laundry dryers, furnaces and warm-air equipment snap-action control—at a competitive price. Two basic styles available: exposed bimetal for rapid response, enclosed bimetal for dust or lint-laden atmospheres. Each is furnished for two or four-hole mounting, either with spade or screw-type terminals. Listed by the Underwriters Laboratories for operation to 300° F.

If your product uses thermostats, check Stemco Thermostats *first*. You'll get *more* thermostat for your dollar . . . *longer* service-free life for your product . . . *more* satisfied customers.

AA 2219



Stemco Type D Thermostats are rated at 25 amps at 120-240 volts on non-inductive; ½ hp at 120-240 volts on 143 volt-amps pilot duty.

STEMCO

THERMOSTATS

STEMCO manufacturing company, Inc.
Lexington and Mansfield, Ohio

UNION CARBIDE has long been closely identified with silicones through the work of its Division, Linde Air Products Company. To an important degree, industry has come to "Look to LINDE for Silicones."

Silicones are incredibly versatile man-made chemicals offering startling advantages in more and more products and processes. You may find that their stability under wide temperature change is the quality that interests you. Or it may be their water repellency, their high electrical resistance, or some other special property.

Interesting new developments, as well as the many proven needs, have now led to the formation by Union Carbide of a Silicones Division. With the world's most modern silicones plant almost ready to go on stream at Long Reach, W. Va., this new Division will be responsible for Union Carbide's program for the development, manufacture, and sale of silicone products.

This is more than just a change of name. While addresses and telephone numbers will remain the same, customers will be served by still further expanded sales and technical staffs.

But of prime importance, it means that through the expanded organization and vastly increased output, Union Carbide will provide more silicone products, in a greater variety, to match the needs of the fast-growing number of its silicone users. If you haven't already checked on the potentialities of silicones in your business, you should. Now, more than ever, it will pay you to . . .

UNION CARBIDE Trade-Mark SILICONES

Look to UNION CARBIDE for silicones

For example, thick silicone rubber sections have been made possible with easily molded and cured LINDE W-96 Silicone, the controlled reactivity gum stock. The same low compression set, resistance to high pressure steam, other highly useful properties, are available to you with UNION CARBIDE W-96 Silicone. Along with UNION CARBIDE Silicone Rubber Compounds like K-1025 and others, it merits your close investigation.

Design with these precision sprockets--

minutes less to install

LINK-BELT ROLLER CHAIN TAPER LOCK SPROCKETS
bring new benefits

for the shop:

▶**QUICK INSTALLATION.** Bushing and sprocket assembly slips easily into position on shaft. Setscrews draw sprocket onto taper bushing, causing bushing to clamp tightly on shaft — equivalent to a shrink fit.

▶**NO REBORING DELAYS.** Bushings are stocked in bore increments of 1/16 in. for shaft sizes from ½ to 4-in. diameters. Sprockets mount with the tightness of a shrink fit.

▶**BROAD RANGE OF SIZES.** Taper Lock Sprockets and matching Precision Steel Roller Chain are stocked in 8 pitch sizes, ½ to 2 in. — an ideal combination from one source.

NEW BOOK 2649 contains complete specifications. Link-Belt Roller Chain Taper Lock Sprockets are usually made of steel. Where size and weight are considerations, spoked cast iron sprockets are furnished.

For your copy or more information, call your Link-Belt Office.

for the machine:

▶**REMOVAL** is easily and quickly accomplished by using setscrew as jack screw in hole provided, which releases sprocket assembly from shaft with a few quick turns.

▶**FULL BEARING, POSITIVE GRIP.** Full length of bushing supports sprocket on shaft. Tapered construction with uniform compression provides tightest, safest grip available.

▶**NEAT APPEARANCE, SAFE, COMPACT.** Flush mounting requires minimum shaft space, and bushing requires no more room than sprocket hub. No projecting bolts or flanges.

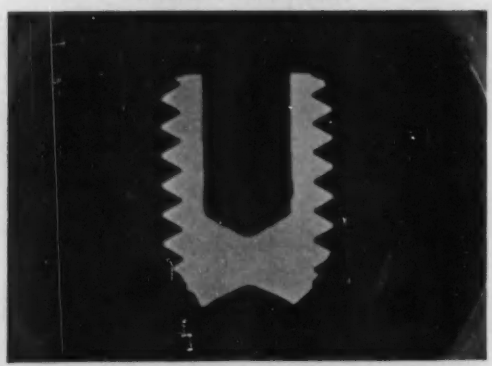
LINK-BELT

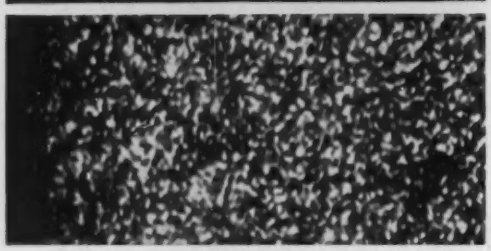
ROLLER CHAIN AND SPROCKETS

LINK-BELT COMPANY: Executive Offices, 307 N. Michigan Ave., Chicago 1. To Serve Industry There Are Link-Belt Plants, Sales Offices, Stock Carrying Factory Branch Stores and Distributors in All Principal Cities. Export Office, New York 7; Canada, Scarboro (Toronto 13); Australia, Marrickville, N.S.W.; South Africa, Springs. Representatives Throughout the World. 13,048

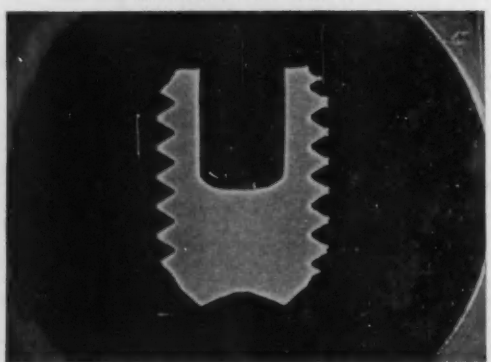
New heat-treatment methods help High-Torque Unbrako socket set screws withstand up to 40% Higher Torques

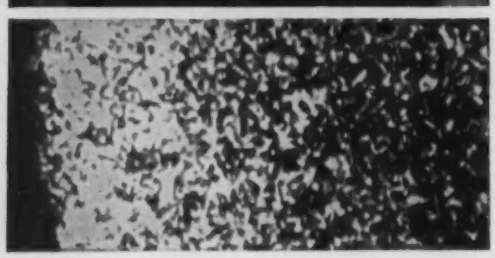
UNBRAKO SET SCREW





ORDINARY SET SCREW





—you can set them and forget them

Research had proved that the tighter you seat a set screw the better it works. So we developed a set screw that could be tightened tighter than ever before without damaging the screw. One of the problems was developing new methods of heat treatment to eliminate decarburization. Decarb of course plays havoc with a screw. Put a wrench in the socket and you ream it. Run the screw into a tapped hole and you strip its threads. Try to seat it and its point shears off. These photographs are a study in contrasts. The UNBRAKO is clean, its grain uniform. There is no decarburization —the ordinary set screw is suffering from an overdose of it, socket walls, threads and point are full of the telltale white spots.

You can't buy a better screw than an UNBRAKO. And you can't get full *high-torque* performance without a "High-Titan" UNBRAKO Hex Key—the high-ductility, precision internal wrenching tool. See your industrial distributor. Or write STANDARD PRESSED STEEL Co., Jenkintown 28, Pa.

RECOMMENDED SOCKET SET SCREW TIGHTENING TORQUES (Inch-Pounds)

SCREW SIZE	UNBRAKO	SET SCREW B	SET SCREW C	MINIMUM DIFFERENTIAL %
#4	5	3.9	3.5	28
#5	9	7.8	7.4	15
#6	9	7.8	7.4	15
#8	20	14.7	14.5	36
#10	33	26.5	25	25
1/4	87	62	60	40
5/16	165	122	125	32
3/8	290	198	225	29
7/16	430	309	350	23
1/2	620	460	500	24
5/8	1225	1106	1060	11
3/4	2125	1540	1800	18
7/8	5000	3660	4600	9
1	7000	5025	6500	8

STANDARD PRESSED STEEL CO.

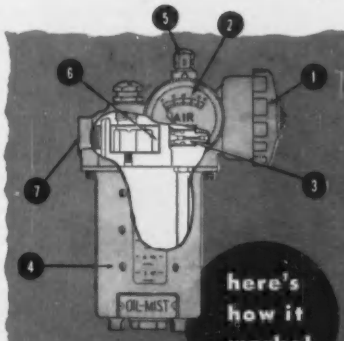
UNBRAKO® SOCKET SCREW DIVISION SPS

JENKINTOWN PENNSYLVANIA

A SIMPLE CONCEPT IN LUBRICATION...

that protects any machine... any bearing surface!

ALEMITE OIL-MIST



here's how it works!

This Oil-Mist lubricator atomizes oil into minute particles which are carried in the air stream through tubing to bearings. Compressed air enters through the air regulator (1) and air gauge (2). As the air passes the venturi (3) it draws oil from the reservoir (4). Oil flow is set by knob (5). The oil-air mixture is thrust against baffle (6), and only the tiniest, lighter-than-air particles are blown through the outlet (7) and through the delivery line to bearings.

Proved in countless applications—*multiplies* bearing life—*slashes* product spoilage—*boosts* machine output!

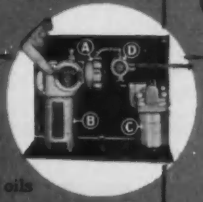
It's a simple idea in lubrication, and like most simple ideas, it's very sound. Easy to incorporate into new designs, equally easy to apply to machines already installed. Oil-Mist applies a constant, clean, cool film of oil uniformly to working parts—bearings, slides, vees, chains, gears—wherever needed. And in the form needed: Liquid, spray or mist. Replaces grease systems. No moving parts—operates on compressed air—completely automatic, fool-proof!

Three types of bearing fittings allow the use of OIL-MIST on any machine!

Oil-Mist fittings bring the most efficient lubrication in the world to any anti-friction bearing—roller, ball, needle.

Spray fittings are recommended for open and enclosed gears and chains. Allow for a concentrated spray of oil where needed.

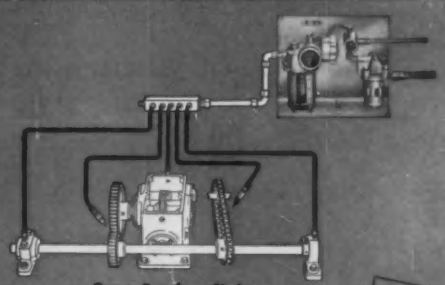
Condensing fittings apply oil in liquid form to plain bearings, slides, ways, vees, cams and rollers.



Lubricator Specifications

- Air regulator (A) reduces from pressures up to 200 psi. Normal air consumption, .7 to 1.2 cfm.
- Operating pressure, 5 to 20 psi. • Range of oils handled: to 1,000 sec. (S.U.V.) @ 100°F.
- Oil reservoir (B) capacity 12 oz. (One week's average supply) • Baffle-type water separator (C) is automatic—self-dumping.
- Solenoid Control (D) starts system as machine starts.

Complete range of models and multiple unit models—Capacities 12 oz. to one gallon to fit any application!



Alemite Oil-Mist offers these lubrication advantages

Automatic lubrication • Continuous lubrication
Eliminates guesswork • Greater safety • Cuts oil consumption up to 90%
Extends bearing life • Stops oil drippage • Saves man-power
Reduces number of lubricants needed • Eliminates "Down-time"

ALEMITE OIL-MIST LUBRICATION

A PRODUCT OF SW STEWART WARNER

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Skinner Valves are available with UL-approved Explosion-Proof construction, and with "Quick Exhaust" for extra-fast cylinder return.

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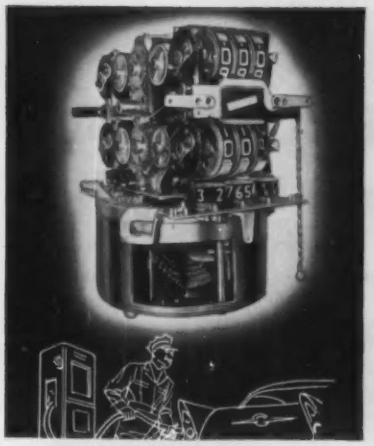
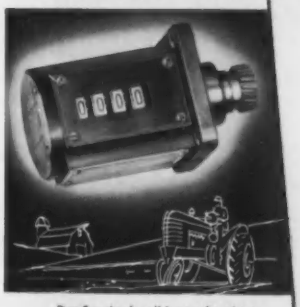


Computing Head for Gasoline Pumps

"Master Meter Duplicator" prints receipts for fuel oil delivered from trucks

"Vary-Tally" Multi-Unit Reset Manual Counter



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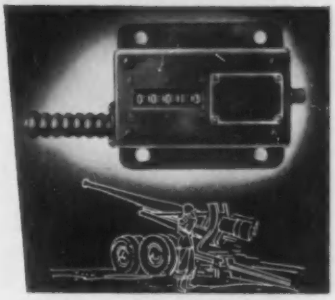
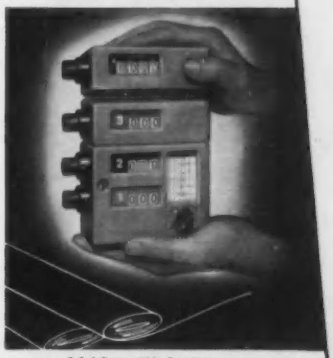
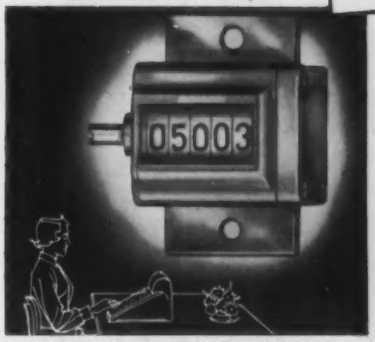


Recoil Counter for new 280 mm atomic cannon



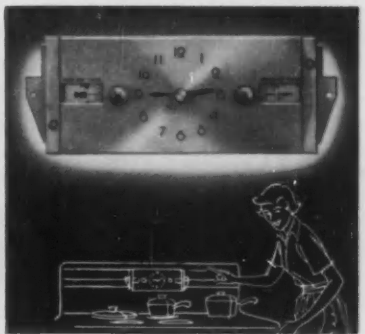
2-3-4 Convertible Counters (and others) for textile machinery

Fuel-Remaining Counter for aircraft . . . subtracts as fuel is used



Small Square-Case Counters for office and other machines

Predetermining Counters for preventing short and over-runs on production machines



Range Timer . . . easy to read . . . easy to set

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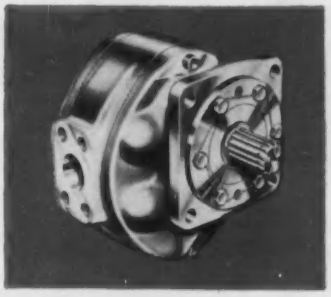
Famous Four-Bolt design, Gear-type Pumps for 1000 and 1500 psi operation in sizes delivering 3 to 110 gpm at 1200 rpm. Also available in Dual and Tandem units.



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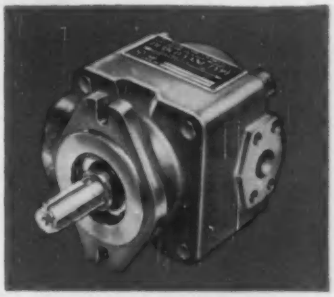

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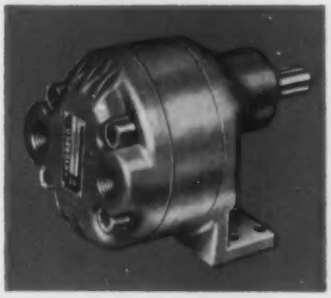
Gear-type Motors in the famous HYDRECO Four-Bolt design featuring high running torques and operating at 1000 and 1500 psi. Flange or foot mounted models developing 0.1 to 60 hp.



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Over 30 standard models for 2000 psi Continuous Operation, torque output from 180 to 14,400 lb.-in. Continuous Running Speeds to 3600 rpm.

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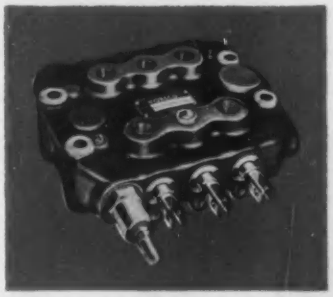
Hollow-Plunger Control Valves with 1 to 6 Plungers in capacities from 5 to 100 gpm for operating pressures of 1500 psi.



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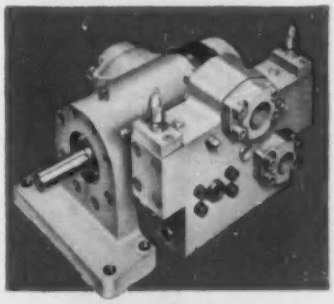
Equipped with Valve Panels. DUDCO Double Pumps provide simple and inexpensive Two-Pressure systems for Machine Tools and Hydraulic Presses.



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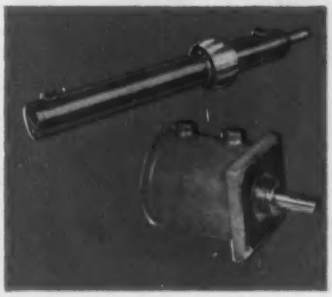

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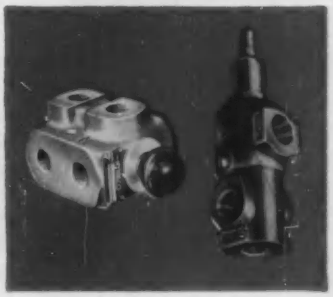
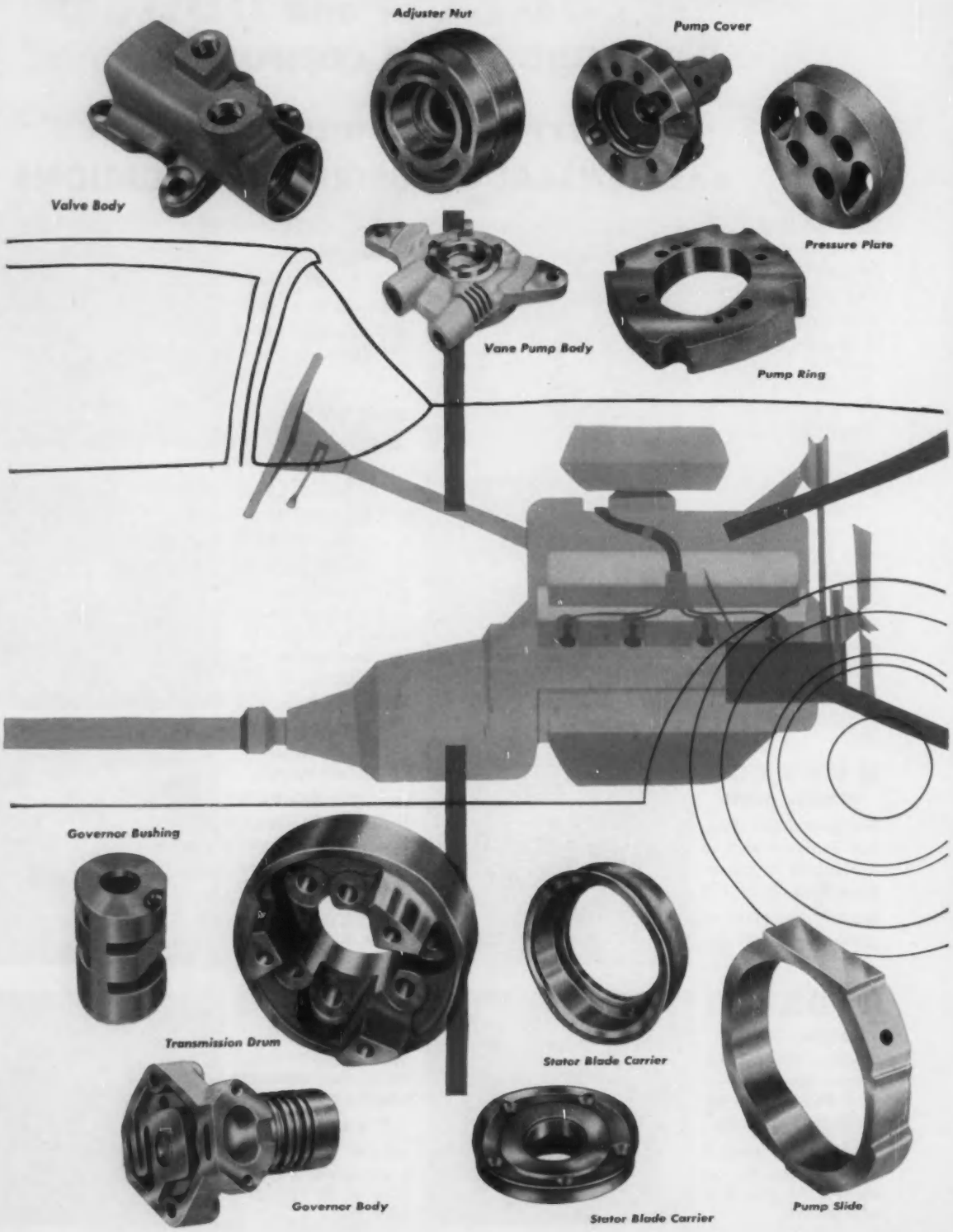
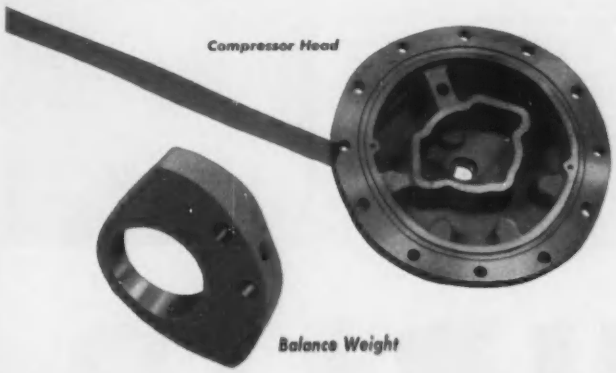
Adjustable Pressure Relief, Pilot Operated Checks and Selector Valves, as well as many Special Purpose Valves in capacities to 100 gpm and 2000 psi.



CENTRAL FOUNDRY SHELL



CASTINGS in the 1956 automobiles



In the steering mechanism, in the transmission, in the air conditioning compressor, and throughout the engine, most of America's fine new 1956 automobiles depend on Central Foundry Division shell castings. Shell castings—produced by the newest of ferrous molding techniques—has resulted in improved products and reduced machining costs to these auto manufacturers. The greater accuracy of the thin shell mold enables Central Foundry Division to cast parts to closer tolerances, thus reducing machining time, and also to cast difficult sections that would be impractical with other ferrous molding methods. Parts that are shell-cast of grey iron, malleable iron, and ArmaSteel in large production quantities by Central Foundry Division, offer advantages of uniformity in many applications . . . they may help your product, too. For further information about our shell casting process, write for descriptive literature . . . or request personal help from our experienced engineers, without obligation.

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57

These turboprop propeller blades

Model CT634S of the Curtiss-Wright Turbolectric series was the first U. S.-designed and built turboprop propeller to be certificated for commercial use by the Civil Aeronautics Administration. This model and others are already in quantity production for military aircraft.

Turbolectric propellers use extruded hollow steel blades produced by the controlled extrusion process developed by Curtiss-Wright. The extruded blade begins as a single-piece alloy steel billet.

With the development of this propeller and the controlled extrusion process came the need to select the right alloy steel. And here's where teamwork paid off.

Republic metallurgists, working closely with Curtiss-Wright metallurgists and engineers, selected an alloy steel with the following properties that make the extrusion process successful from both a production and cost standpoint: freedom from imperfections, uniform response to heat treatment, workability in all stages, weldability, bendability—hot or cold.

These properties in combination with the extrusion process give:

(1) **IMPROVED STRENGTH-WEIGHT RATIO.** The tough, integral structure of the extruded alloy steel blade provides greater strength and resistance to fatigue with minimum weight.

(2) **IMPROVED QUALITY.** Greater uniformity is assured by fabricating from a single homogeneous material.

(3) **INCREASED PRODUCTION.** The number of manufacturing operations is reduced. Production per hour is increased. Floor space is saved.

(4) **REDUCED COST.** Less steel for original stock, less machining, and lower cost tooling and equipment are required. Expensive welding and accompanying preheating and post-heating operations, as well as milling operations, have been reduced.

What about your product? Are you using the right steel in the right place? Republic—world's largest producer of alloy and stainless steels—offers you the services of experienced field metallurgists who will work with your staff in determining where these versatile steels can effect the greatest savings. Just send us the coupon.

Strength-to-Weight or Heat Problems—Republic Has the Answers

◀**TITANIUM SAVES WEIGHT ON DC-7** with no sacrifice in strength or safety. Republic is an old hand at this high strength-to-weight business. We pioneered the use of alloy steels, then stainless steels—followed by high strength steels. Now come Republic Titanium and Titanium Alloys. Years of experience gained in helping hundreds of manufacturers design and re-design their products to get more strength with less weight are available to you.

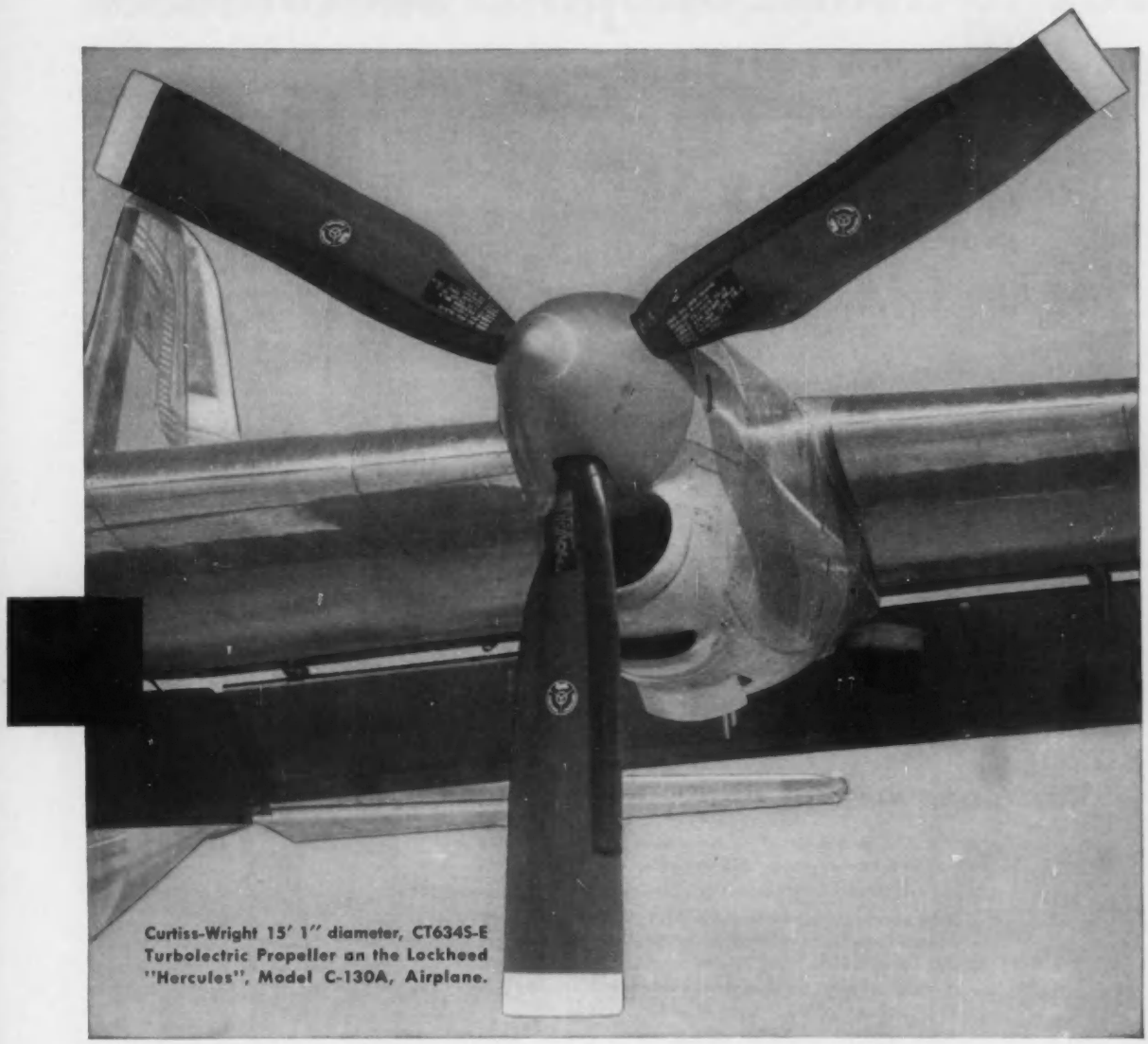
600° F TEMPERATURE HAS LITTLE EFFECT ON DE-ICER DUCTS made of Republic▶ ENDURO Stainless Steel. Because of its extremely high strength-to-weight ratio, and corrosion-resistance you can use ENDURO in thinner, lighter sections. It resists temperature extremes, holding its strength, toughness, and shock-resistance all the way from blistering heat through sub-zero cold. Republic produces ENDURO® in all commercial forms.

REPUBLIC

REPUBLIC STEEL

World's Widest Range of Standard Steels

begin as alloy steel billets



Curtiss-Wright 15' 1" diameter, CT634S-E Turboelectric Propeller on the Lockheed "Hercules", Model C-130A, Airplane.

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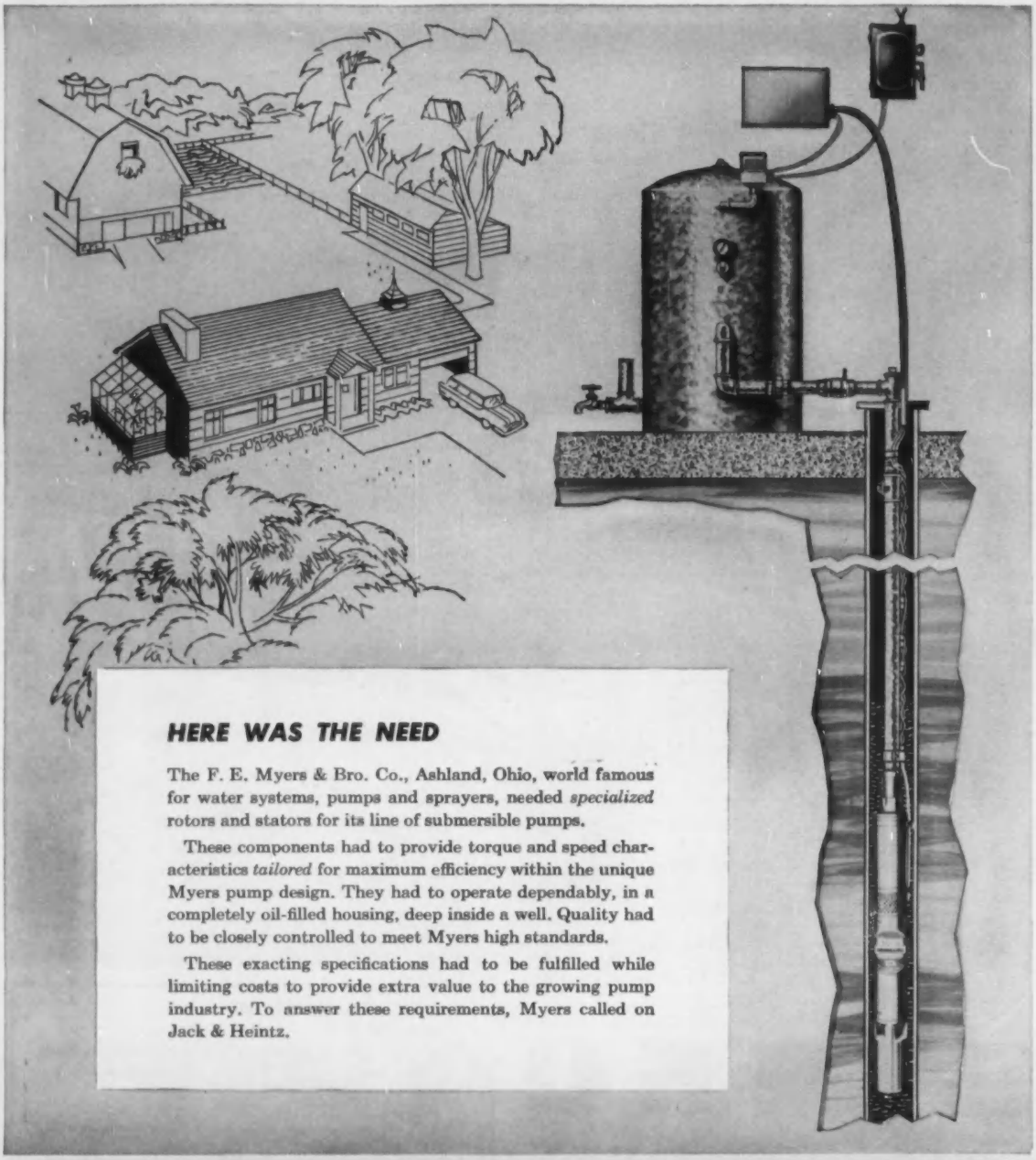
Jack & Heintz supplies customized



HERE WAS THE NEED

The F. E. Myers & Bro. Co., Ashland, Ohio, world famous for water systems, pumps and sprayers, needed *specialized* rotors and stators for its line of submersible pumps.

These components had to provide torque and speed characteristics *tailored* for maximum efficiency within the unique Myers pump design. They had to operate dependably, in a completely oil-filled housing, deep inside a well. Quality had to be closely controlled to meet Myers high standards.

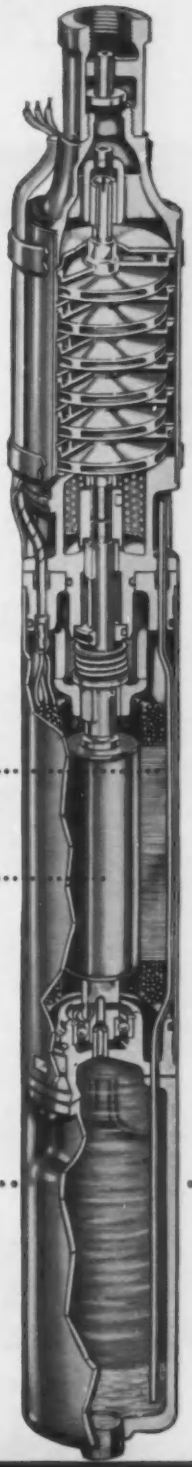
These exacting specifications had to be fulfilled while limiting costs to provide extra value to the growing pump industry. To answer these requirements, Myers called on Jack & Heintz.

Customized ELECTRIC

motor components for

Myers

Submersible Pumps



Jack & Heintz accepted the responsibility of designing and manufacturing basic customized motor components in accordance with the typically high standards of the Myers-built pumping unit—designed to work under water for thousands of service-free hours.

STATOR

Special windings were designed to furnish the exact operating characteristics to meet the Myers specifications. Special insulating materials were developed, completely impervious to the oil in which they operate.

ROTOR AND SHAFT ASSEMBLY

The rotor was developed with the maximum amount of copper to achieve the highest possible speed at full-load torque. Silver alloy induction brazing makes it an indestructible mass. Tolerances on the rust-resistant shaft are held strictly to Myers specifications . . . with precision balancing to prevent vibration.

In addition, highly specialized methods and processes were developed by Jack & Heintz to provide manufacturing economies consistent with the needs of an expanding market for Myers submersible pumps.

DESIGN YOUR PRODUCT TO DO A JOB . . .

not to fit a motor

Avoid compromising your product design by taking advantage of an engineering philosophy that will answer your special motor needs. Design your product to do a job . . . *not to fit a motor!* Write Jack & Heintz, Inc., 17627 Broadway, Cleveland 1, Ohio.

© 1956, Jack & Heintz, Inc.

MOTORS *by* JACK & HEINTZ

Aluminum part cuts costs

Screw Machine Data—Aluminum Windshield Wiper Knob Insert—Ford Motor Company

MACHINE: 5 Spindle Davenport Automatic

OPERATING DATA:

Turning—3000 R.P.M.—295 S.F.P.M.

Knurling—Diamond knurl—3000 R.P.M.—295 S.F.P.M.

OPERATIONS: Feed, Center, Drill, Knurl, Form, Cut-off

CYCLE TIME: 2.4 seconds

PARTS PER HOUR: 1500

EFFICIENCY: 80%

STOCK: ⅜" round, aluminum 2011-T3

for Ford Motor Company

THE Ford Motor Company recently changed its specifications on the Ford car windshield wiper knob insert to aluminum. This Ford part is one of several new screw machine parts now made from aluminum. They are currently studying other screw machine parts for possible conversion to aluminum.

This conversion met the requirements of management, design engineering and production groups.

MANAGEMENT REQUIREMENT: Savings

Change to aluminum saved approximately 24.8%. Ford management is always interested in materials or methods that will effect savings with no sacrifice in quality. In this particular case, as in others, aluminum seemed to be the logical material because it provided savings of about 24.8% per piece, including scrap loss. Also, the aluminum parts are so much lighter than the previously used metal, that Ford has realized additional savings in shipping costs.

DESIGNER REQUIREMENT: Performance

Aluminum met design specifications. Ford engineers selected aluminum alloy 2011-T3, ⅜" round stock after they tested other metals and found that the aluminum knob insert would not only provide sufficient strength but would also take a slightly better knurl. The fact that aluminum satisfied performance requirements and for less money than other metals tested, was the main consideration in Ford's selection of aluminum.

OPERATOR REQUIREMENT: Machinability

Aluminum machined at maximum efficient cutting speed. The changeover to aluminum for this knob insert did not require any change in machining speed and setting from the previous metal used. Ford is running the part successfully at the maximum efficient speed of the automatic screw machine. And Ford found that it was not even necessary to change the angle of the form tool, which is an ordinary high speed steel tool with no chip-breaker.

The experience and engineering know-how of Ford has proved that properly designed aluminum parts can often provide substantial economies plus high quality.

Aluminum Screw Machine Stock Offers These Big Advantages

You get three times as many parts from a pound of Kaiser Aluminum stock as from a pound of brass or steel. And you often get *better* parts because aluminum provides a unique combination of advantages, including lightness with strength, handsome finish, corrosion resistance, good heat and electrical conductivity.

For more information or assistance, look for our local number in the classified telephone directory under the heading "Aluminum."

Kaiser Aluminum & Chemical Sales, Inc. *General Sales Office*, Palmolive Building, Chicago 11, Illinois; *Executive Office*, Kaiser Building, Oakland 12, California.

Kaiser Aluminum

setting the pace—in growth, quality and service

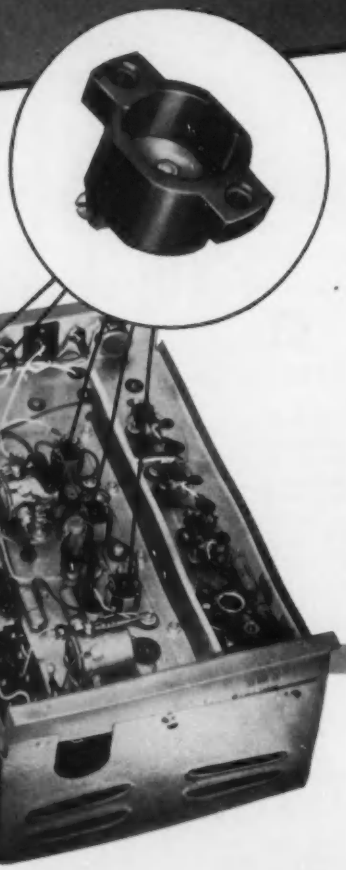
Apelco

USES

KLIXON

Circuit Breakers

For Dependability Under the Most Rugged Conditions



The new, powerful AE-156-CM Marine Radiotelephone manufactured by Applied Electronics Company, Inc., San Francisco, California, incorporates every element essential to dependable local and long distance radiotelephone performance.

To insure the best in protection of power supply circuits, Apelco uses Klixon Circuit Breakers. Here's what Mr. S. S. Konigsberg, President, writes:

"You will note that there are five Klixon Circuit Breakers in use in the power supply. As the power supply is the source of current to motivate the radiotelephone, you can see how important it is to use reliable components. It must be able to perform at all times and under the most rugged circumstances.

"Apelco has found that Klixon Circuit Breakers go on the job and keep on with the least possible attention. As we make over fifty different power supplies for the extensive line of radiotelephones we manufacture, you may see what an important part they are of our program."

What's your control problem . . . circuit protection, low or high temperature limitation, fuel delay, tube and rectifier cooling, fan or burner operation . . . Klixon Circuit Breakers and Thermo-Snap® Controls are successfully meeting hundreds of requirements for a variety of such applications in military and civilian equipment, daily.

Klixon Circuit Breakers and Thermo-Snap Controls are available in hermetically sealed and open types with fixed temperature settings to meet your needs.

Our Field Engineers will gladly help you work out application details . . . no obligation, of course.

KLIXON

METALS & CONTROLS CORPORATION
SPENCER THERMOSTAT DIVISION
902 FOREST STREET, ATTLEBORO, MASS.

Two Metals are often Better Than One

General Plate Composite Metals, made by joining two dissimilar metals together with an inseparable bond, offer many advantages not always possible in a single metal.

Consider CONFLEX — a General Plate Composite Metal of hardenable steel faced on one or both sides with sheet copper. CONFLEX is a superior spring material, yet it offers better electrical conductivity and greater strength — at lower cost — than comparable copper alloys.

It can be easily formed before hardening — then heat treated to the desired spring characteristic with greater uniformity. In mechanical springs, such as pen and pencil clips, the copper surface is excellent for electroplated finishes.

CONFLEX is available in long length coils slit to desired widths for automatic machine feeding. All in all it offers many advantages in the manufacture of electrical and mechanical spring parts.

...and General Plate CONFLEX* is a case in point

Why not get acquainted with CONFLEX by sending for a free sample today?

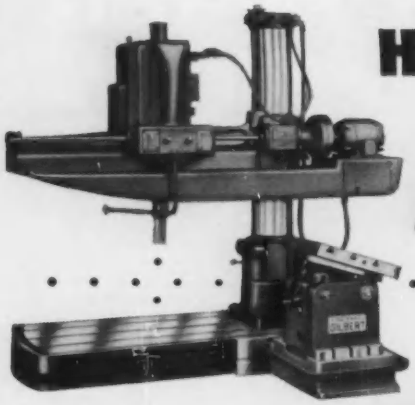
If you are looking for stronger or lighter metal components, with better electrical and mechanical properties and fewer corrosion problems, or if you are interested in conserving critical metals or reducing parts costs, you should be investigating General Plate Composite Metals. Catalog PR-700 covering precious to base and base to base cladments, TRUFLEX® Thermostat Metals, composite electrical contacts, buttons and rivets, etc. sent free. Write for it!

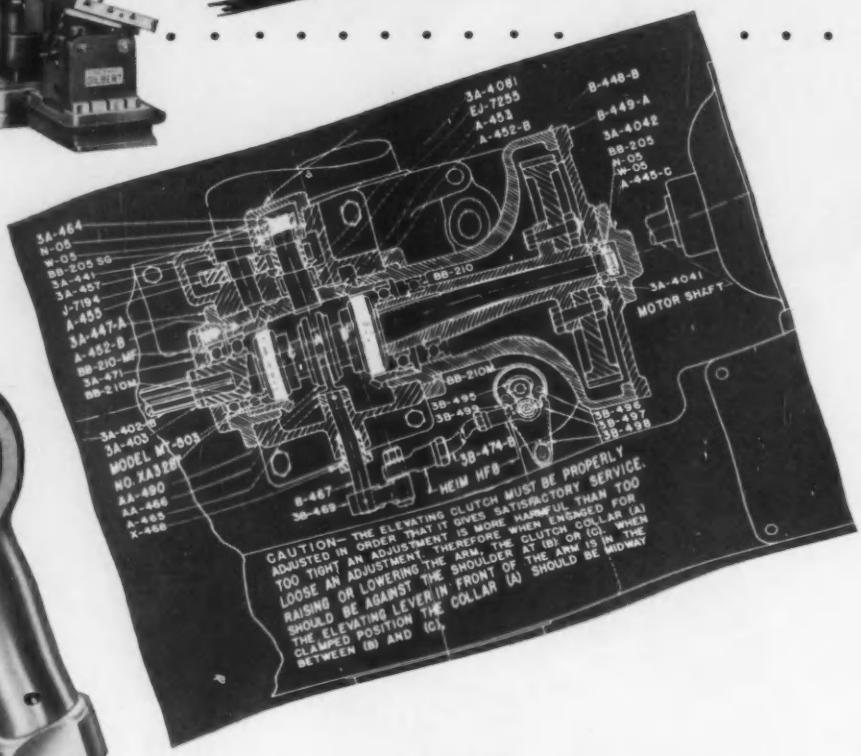
*Trade Mark of Metals & Controls Corporation

You can profit by using General Plate Composite Metals!

METALS & CONTROLS CORPORATION
GENERAL PLATE DIVISION
12 FOREST STREET, ATTLEBORO, MASSACHUSETTS

HEIM *Unibal* ROD END *Was All We Could Use!*





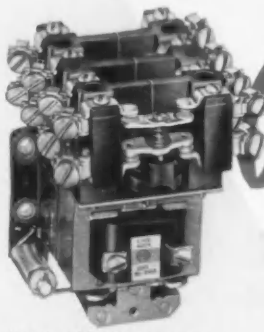
The Cincinnati Gilbert Machine Tool Co. manufactures the Gilbert Radial Drilling Machine. In the linkage mechanism which controls the elevating clutch adjustment, an offset link and misalignment correction had to be provided for. Specially designed and carefully machined parts could be made but at costs too high to be within reason.

The Heim catalog shows the complete line of bearings and rod ends. A copy should be in your engineering department.

The HEIM Unibal Rod End was found to be the perfect solution to this linkage problem, and is now used in all Gilbert machines.

Heim Unibal Rod Ends reduce friction and lost motion in linkages; they eliminate the effects of vibration; they are more economical than specially made parts; their ease of installation helps lower costs; they carry heavier loads; and they correct misalignment in all directions.

THE HEIM COMPANY, FAIRFIELD, CONNECTICUT.

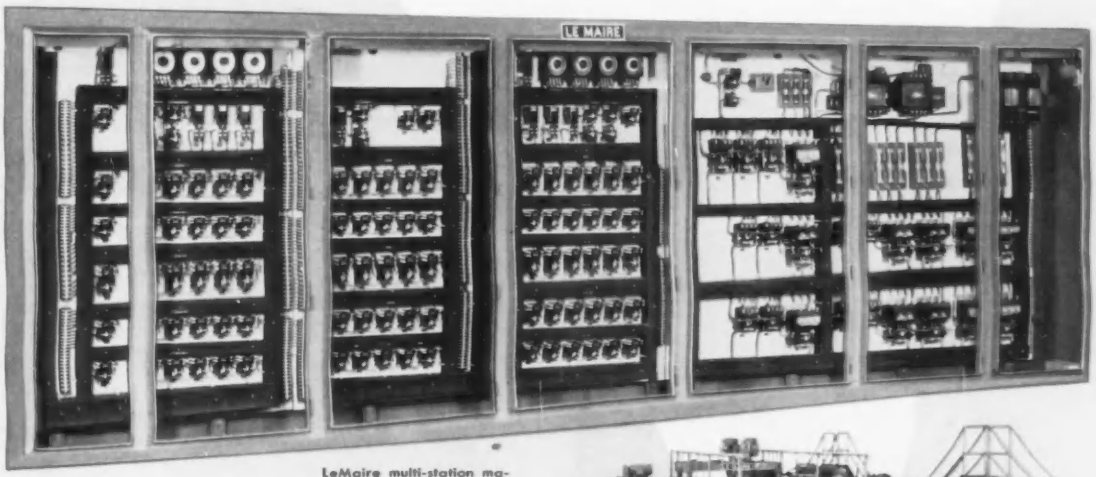


Bulletin 700 BX Universal relay with 4 normally open & normally closed contacts.

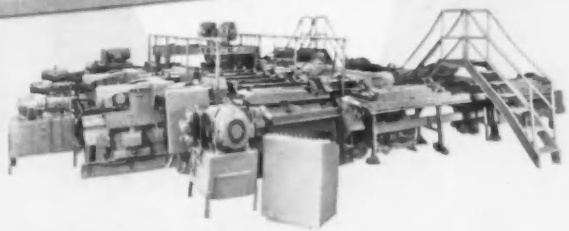
OVER 125 ALLEN-BRADLEY

RELAYS, TIMERS and STARTERS

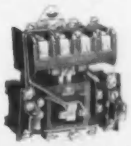
in this LEMAIRE Multiple Station Machine Panel



LeMaire multi-station machine operated by panelboard shown above. A good example of Allen-Bradley solenoid controls in the automotive industry.



Bulletin 709 Size 3 starter. Rated 30 hp, 220 v; 50 hp, 440-550 v.



Bulletin 709 Size 1 starter. Rated 5 hp, 220 v; 7½ hp, 440-550 v.

Bulletin 702 3-pole relay with magnetic hold-in latch. A hum-free relay.

Did you notice the prominence of Allen-Bradley solenoid motor controls at the recent Chicago Machine Tool Show? Manufacturers recognize these reasons . . . the long, trouble free life of Allen-Bradley motor controls . . . their unerring precision in operation . . . the inherent QUALITY of their workmanship and materials.

Machinery manufacturers look to Allen-Bradley as a reliable source of control units and components. The A-B trademark is to them and their customers The Sign of QUALITY in Motor Controls.

Send for the Allen-Bradley Handy Catalog. It is a recognized handbook on motor control. Or, let our control specialists help you with your control problems.

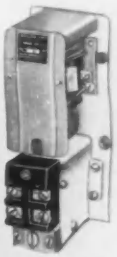
Allen-Bradley Co., 1316 S. Second St., Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

A-B Quality

ALLEN-BRADLEY
QUALITY
TROUBLE FREE
MOTOR CONTROL

Bulletin 800T oiltight push button with NO & NC contacts.

Bulletin 802T adjustable lever limit switch.

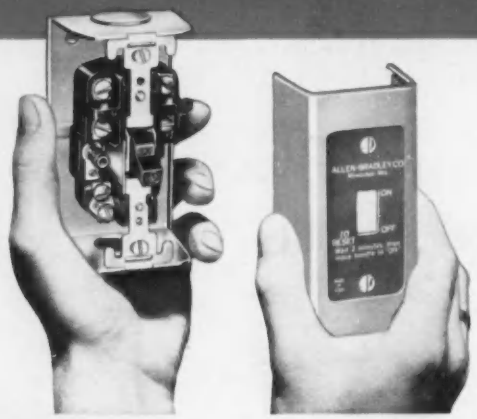


Bulletin 849 pneumatic timer—adjustable from 1/10 to 180 sec.

2-56-R

SMALL MOTORS
need overload protection too!

BULLETIN 600 STARTING SWITCH



Because

SMALL MOTORS CAN BE AS IMPORTANT TO PRODUCTION SCHEDULES AS LARGE MOTORS

Here is an outstandingly popular starter for applications using motors of ONE HORSEPOWER OR LESS.

It is a small, manually operated starter that is equipped with a time-tested, reliable A-B overload breaker. A soldered ratchet trips the operating lever in case of a sustained overload. It is reset, after tripping, merely by moving the operating lever to the OFF position. Overload heater elements are available to cover the ratings of this starter.

The Bulletin 600 starting switch is available in single and double pole construction. Its double break, silver alloy contacts provide high interrupting capacity. The contacts are always in good operating condition. They never need to be cleaned, filed or dressed. Please write for a copy of Bulletin 600 for complete information on the Bulletin 600 line.

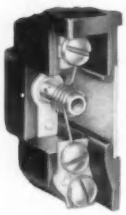
SIMPLE DESIGN

Simple ON & OFF snap switch . . . easy access to terminals . . . ample wiring space . . . silver alloy contacts need no cleaning or maintenance.

ATTRACTIVE APPEARANCE

Streamlined enclosure in grey enamel, and bonderized to assure positive binding of enamel finish to resist corrosion. The pilot light is optional.

OVERLOAD BREAKER



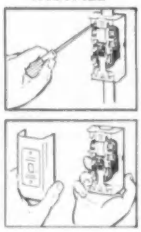
According to National Elec. Code ruling, motors of 1 hp or less, automatically started by thermostat, float switch, etc. must have overload protection.

FITS STANDARD SWITCH BOXES

Bulletin 600 starters fit any standard 2½ in. deep wall switch box.

Can be mounted in machine frame or base. Available with pilot light.

EASY TO INSTALL

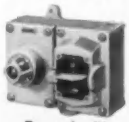


Remove 2 screws on front of starter . . . slip off cover . . . attach conduit . . . pull in wires and connect to terminals . . . replace the cover.

VARIETY OF ENCLOSURES

Type 7 for hazardous locations.

Type 4 watertight.



Type 4 with pilot light.

Allen-Bradley Co.
1316 S. Second St.
Milwaukee 4, Wis.
In Canada—Allen-Bradley Canada Ltd., Galt, Ont.

A-B Quality

ALLEN-BRADLEY

BULLETIN 600 STARTING SWITCHES

QUALITY

2-56-MP

620 lbs. lighter, more portable, and more durable . . .

Welded Assembly of USS "T-1" Steel Cuts Grapples Weight 47%

It isn't the logs that wear out log grapples like these. But dropping the grapples 10, 25, or 30 feet, twice a minute, hour after hour, day after day, does wear them out. They literally destroy themselves. That's why light weight is important. And toughness. And strength.

Mack Welding Company, Duluth, Minnesota, has cut weight of grapples 620 lbs. and simultaneously *increased* durability, just by switching from mild steel to rugged USS "T-1" Steel. Here is what they say about "T-1":

"We thought we had reached the lowest possible weight when we manufactured a previous model weighing 1300 pounds. But these new grapples made from your 'T-1' Steel weigh only 680 pounds—just a little over half as much. That's an important advantage for loggers who have relatively small-capacity truck-mounted cranes. No other rolled steel plate would give us such light weight in grapples capable of handling up to 3 ton loads."

"T-1" WELDS BEAUTIFULLY!

"As far as fabrication is concerned, we find that 'T-1' Steel welds beautifully and can be flame cut in exactly the same way as mild steel, without distortion or any other difficulty. We're very pleased with it."

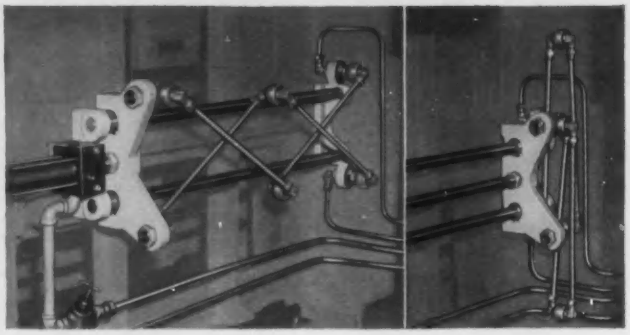
"T-1" Steel is unique. For it gives you a combination of high tensile and yield strength (105,000 psi and 90,000 psi), good high temperature strength, extreme toughness at sub-zero temperatures, good resistance to abrasion, impact, and abuse. You get all of these properties in one steel that is easy to weld.

You can use "T-1" to reduce weight . . . to lengthen service life . . . to reduce costs. Look around you. You'll find a job for it—a job that no other steel can do so well. United States Steel, Room 5188, Pittsburgh 30, Pa.

UNITED STATES STEEL CORPORATION, PITTSBURGH • COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALA.
UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS, COAST-TO-COAST
UNITED STATES STEEL EXPORT COMPANY, NEW YORK

USS "T-1" CONSTRUCTIONAL ALLOY STEEL

UNITED STATES STEEL



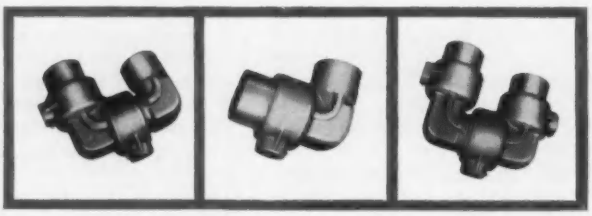
Chiksan Swivel joints, with full 360° rotation allow duplicate sets of lines (left) to be compacted into small spaces (right).

PROBLEM: EXTREME BEND RADII

SOLUTION: **CHIKSAN SWIVEL JOINTS**

Got a bend radii problem? Then let Chiksan engineers go to work on the answer. Chiksan has the years of experience and know-how to handle your problem quickly, efficiently.

Chiksan Swivel Joints provide unlimited flexibility in a compact package to meet your exacting pressure and temperature requirements. Be it for air, hydraulics, fuel, oil, water or other fluids, it will pay you to have Chiksan provide the right swivel joint for *your* bend radii problem.



Typical Chiksan Swivel Joints

FOR FREE CATALOG WRITE DEPT. 172.

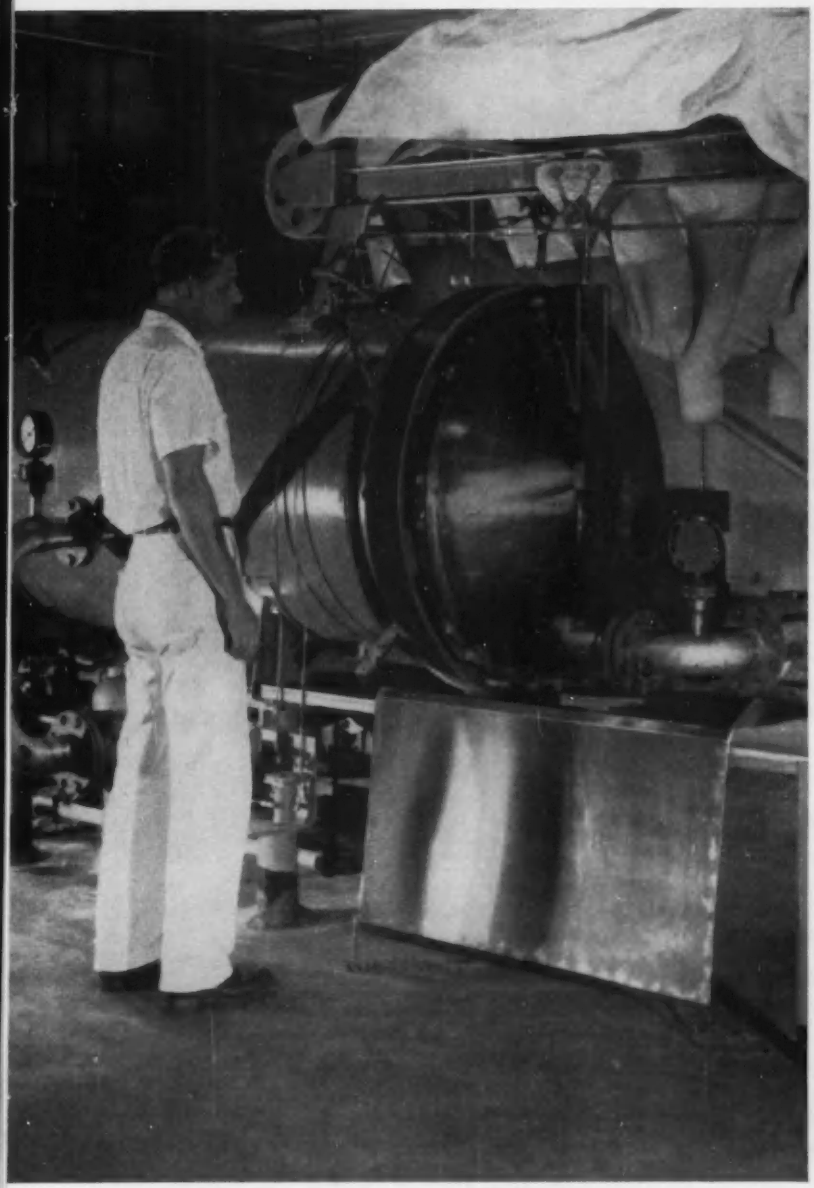
CHIKSAN

A SUBSIDIARY OF FOOD MACHINERY AND CHEMICAL CORPORATION

CHIKSAN COMPANY — BREA, CALIFORNIA • CHICAGO 3, ILLINOIS • NEWARK 2, NEW JERSEY

Well Equipment Mfg. Corp. (Division), Houston 1, Texas • Chiksan of Canada, Ltd., Edmonton, Alta.

NOTHING *can equal Stainless Steel*



FOR CORROSION RESISTANCE. The Norwich, N. Y. plant of Norwich Pharmacal Company is a magnificent display of Stainless Steel. Shown here is a Stainless Steel filter, used to separate mother liquor from the solids of furoxone. Here, Stainless outlasts any other practical metal by two to one.

FOR EASY CLEANING. In this textile plant of W. J. Dickey & Sons, Inc., dyeing time *and* costs have been cut 50% with the use of Stainless Steel equipment. When colors are changed, tanks don't have to be boiled out. With its smooth, dense surface, Stainless can be cleaned easily and quickly.

FOR CONSUMER APPEAL. Now, just about every housewife knows what Stainless Steel is. When she sees the Stainless tub in this automatic laundry, made by Speed Queen Corp., Ripon, Wis., she knows that there is nothing to corrode. She knows, too, that the Stainless tub will stay bright and clean and will last forever.

No other design material can match Stainless Steel in its *combination* of desirable properties: corrosion resistance, strength and hardness, beauty, cleanability and easy fabrication. When buying Stainless, remember that United States Steel offers the widest range of types, finishes and sizes available in the United States.

USS STAINLESS STEEL

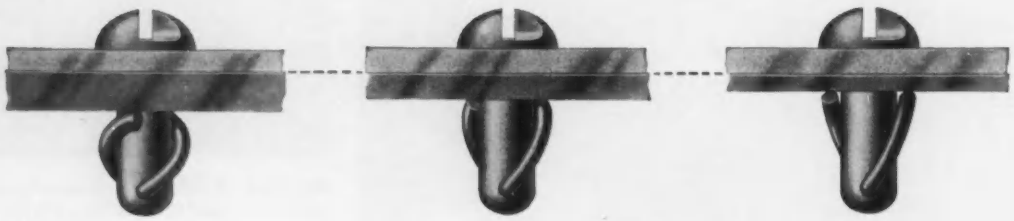
SHEETS · STRIP · PLATES · BARS · BILLETS · PIPE · TUBES · WIRE · SPECIAL SECTIONS

USS

UNITED STATES STEEL

UNITED STATES STEEL CORPORATION, PITTSBURGH · AMERICAN STEEL & WIRE DIVISION, CLEVELAND · COLUMBIA-GENEVA STEEL DIVISION, SAN FRANCISCO · NATIONAL TUBE DIVISION, PITTSBURGH
TENNESSEE COAL & IRON DIVISION, FAIRFIELD, ALABAMA · UNITED STATES STEEL SUPPLY DIVISION, WAREHOUSE DISTRIBUTORS · UNITED STATES STEEL EXPORT COMPANY, NEW YORK

This fastener works through thick and thin!



Spring-Lock—the easy-to-use removable fastener for modern designs—works whether panel thicknesses run over or under specifications! Spring wire deflects automatically to handle greater or lesser thicknesses. Spring-Lock's design flexibility makes it more than a fastener: it can be adapted as a shelf support, door strike, knob or any similar panel-mounted device. Many standard shapes and sizes of Simmons Spring-Locks are available from stock.

SIMMONS FASTENER CORPORATION

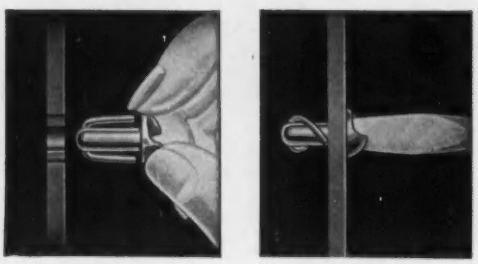
1751 North Broadway, Albany 1, New York

Simmons

QUICK-LOCK
SPRING-LOCK
ROTO-LOCK
LINK-LOCK
DUAL-LOCK

JUST OUT!
NEW 36-PAGE CATALOG WITH APPLICATIONS
SEND FOR IT!

HERE'S HOW SPRING-LOCK WORKS

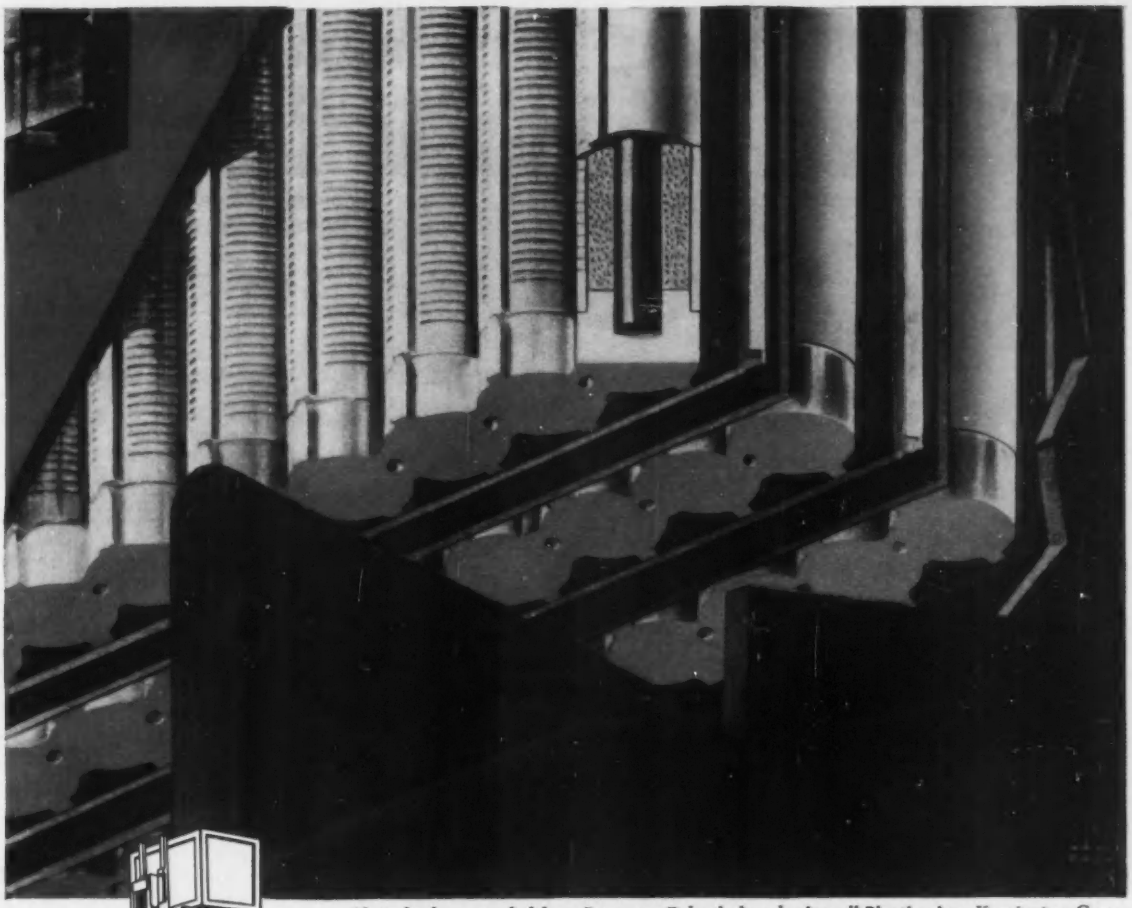


1. *Insert fastener.* **2.** *Half-turn locks it in place.*

With production costs on the uptrend, you can figure on Spring-Lock as an assembly time and money-saver, because:

- **Installation is BLIND**
- **Installation is EASY: no special tools are needed**
- **Installation is QUICK: a half-turn locks it in place**
- **Installation is SECURE: the *spring* steel *locks* the fastener, resists vibration**

Send for details and samples, or write us about *your* fastening problem.



Slotted tubes extruded from BAKELITE Polyethylene by **Jessall Plastics, Inc.**, Kensington, Conn. for the Exide Industrial Division of The Electric Storage Battery Company, Philadelphia 2, Pa.

Corrosion-Resistant Polyethylene Parts Boost Battery Power, Working Life

The new "Exide" "Ironclad" battery was developed for heavy-duty service . . . for example, powering of lift trucks. It's got the usual dimensions, but it's a bigger battery. According to the manufacturer, it packs 20 per cent more power . . . delivers 100 per cent capacity initially (not the ordinary 85) . . . and its working life is longer than that of earlier models.

New design and a new material made it possible. Finely slotted tubes extruded from BAKELITE Brand Polyethylene hold the active material of the positive plates. They permit maximum exposure to the electrolyte. And being BAKELITE Polyethylene, they don't corrode and shorten battery life. To complete the picture, the bottoms of the tubes are closed with sealers molded from BAKELITE Polyethylene.

Corrosion resistance is just one important advantage of BAKELITE Polyethylene. This material is readily molded or extruded into finely detailed shapes. It is the lightest commercial plastic. Dielectric properties are outstanding. It is supplied in a wide range of colors.

The properties of BAKELITE Polyethylene may be important to your product planning. For more information, write Dept. LC-145.

BAKELITE
BRAND
Polyethylene Plastic

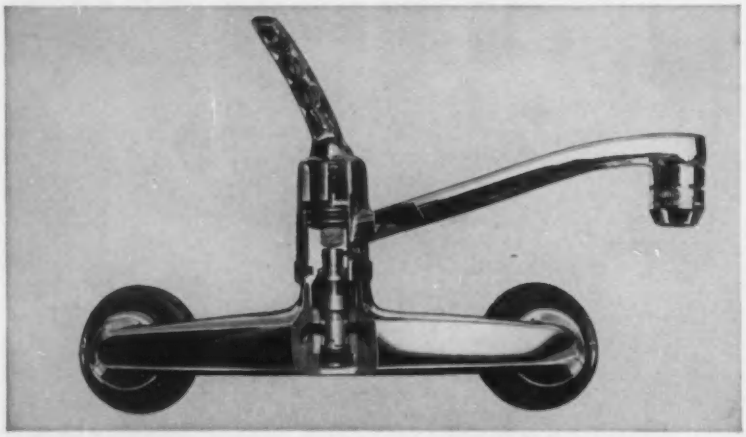
BAKELITE COMPANY, *A Division of Union Carbide and Carbon Corporation* UCC 30 East 42nd Street, New York 17, N. Y.
In Canada: Bakelite Company, Division of Union Carbide Canada Limited, Belleville, Ontario
The term BAKELITE and the Trefoil Symbol are registered trade-marks of UCC

BRIDGEPORT BRASS COMPANY

COPPER ALLOY BULLETIN

Bridgeport Brass Co.

Reporting new developments in copper-base alloys and metalworking methods.



Modern, Single-Handle Faucet Relies on Bridgeport Alloys for Precision-Fit Parts

A practical answer to scalded hands at the kitchen sink is the ingenious, precision Moen faucet made by Ravenna Metal Products Corporation, Seattle.

Replacing the traditional valve-and-washer system with a stem and ported-piston assembly, this faucet mixes hot and cold water to temperatures predetermined by the position of its single handle. Precision-fitted parts eliminate washers and assure watertight connections.

Recognizing that a simplified design often requires expert metallurgical and production knowledge to specify the proper materials, Ravenna asked Bridgeport Technical Service for assistance in materials selection.

This new faucet design placed double responsibility on the materials. All had to meet stringent machining requirements. Each finished part had extensive performance specifications. During test runs with conventional alloys, machining difficulties occurred. Then service failures developed, season-cracking among them.

Technical Service studies for Ravenna indicated that certain Bridgeport alloys, made to ASTM specifications with exact tempers and stress relief anneals, would meet all requirements. And, all machined parts could be made by straight machining on Ravenna's standard Warner & Swasey automatics.

For the spray, valve escutcheon and escutcheon nut, specifications stipulated the use of hard-temper Bridgeport Alloy T-64. Supplied in tube form, this high-leaded alloy is ideal for operations involving extensive machining.

For packing nut, spout end, brass body, body nuts, lock nut and jam nut, the specifications called for Ledrite 6 half-hard brass rod. This is a free-cutting alloy uniform in composition. It assures accurate dimensions and minimizes tool wear.

For spout tubing Bridgeport recommended light-drawn Alloy 69, a cartridge brass, highly ductile and well adapted to both cold-working and severe forming operations.

Radically different requirements were necessary for the anchor washer and discs. Here the studies recommended the use of Bridgeport F-3034 10% Phosphor Bronze D because its characteristics facilitated manufacturing and gave desired wear resistance.

In every instance, Ravenna has found that the alloy characteristics essential to manufacture also assure satisfactory service life in the finished product.

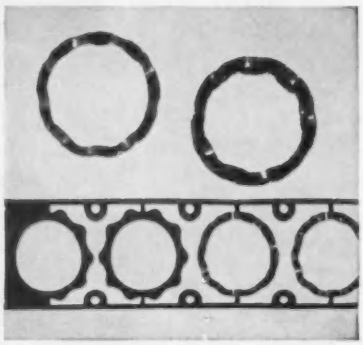
Whenever you plan to simplify or redesign your products, let Bridgeport Technical Service contribute its metallurgical studies and recommendations. This service, available from Bridgeport Sales Offices, can help you achieve manufacturing efficiency and product satisfaction.

Unique Ball Bearings Use Retainer Cages of Bridgeport Brass

Stephens-Adamson Manufacturing Company of Aurora, Illinois, produces the well-known Sealmaster ball bearing unit, widely used in mining, agriculture, textile and heavy-duty applications. Sealmaster bearings are designed to operate under severe atmospheric conditions with a minimum of maintenance.

Unique bearing cages accurately space the balls to distribute radial and thrust loads and at the same time trap and hold grease and prevent its churning. To make these retainer cages, Stephens-Adamson uses Bridgeport F-37 cartridge brass, soft, as recommended by Bridgeport Technical Service.

Smaller cages are made by progressive die operations. Larger cages are press-formed from blanked-out rings, the separate halves being riveted together.



Bridgeport Alloy F-37, developed primarily for the production of artillery shells and small arms cartridges, is a superior material for products which are deep-drawn, spun or progressively machined.

For Sealmaster bearings, Alloy F-37 is supplied in widths up to 9 inches. The easy working qualities of this Bridgeport alloy make it ideal for this application. In other cases, too, there is usually a preferable Bridgeport alloy. Technical Service can help you find it. A call to your nearest Bridgeport Sales Office will make all arrangements.

(4626)

Bridgeport Brass Co.

BRIDGEPORT BRASS COMPANY ◆ BRIDGEPORT, CONNECTICUT

Mills at Bridgeport, Conn., Indianapolis, Ind., and Adrian, Mich. Sales Offices in Principal Cities—Conveniently Located Warehouses

(Advertisement)

Design data on adhesives

NUMBER ONE

Armstrong

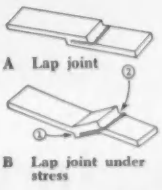
ADHESIVES • COATINGS • SEALERS
. USED WHEREVER PERFORMANCE COUNTS

How to design joints for adhesives

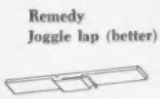
Many common joints can be re-designed to give maximum strength with adhesives. The examples shown do not cover every situation, but they do illustrate how four basic design rules can be applied to improve strength. These rules are:

1. Make the bonded area as large as possible.
2. Make the maximum proportion of bonded area contribute to strength.
3. Stress the adhesive in the direction of its maximum strength.
4. Minimize stress in the direction in which the adhesive is weakest.

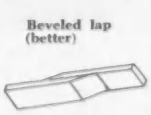
Strengthening a lap joint:



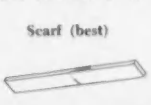
Under stress, a common lap joint such as "A" tends to deflect as the assembly aligns itself. Instead of a simple shear stress, the joint in effect more nearly resembles drawing "B". The tension effect at edges "1" and "2" tends to peel the bond apart, since a high proportion of the load is carried at the edges of the lap.



Greater proportion of bonded area now contributes to strength. (Rule 2) Stress is now reduced in the direction in which the adhesive is weakest. (Rule 4)



Even greater proportion of bonded area now contributes to strength (Rule 2) Stress is further minimized in the direction in which the adhesive is weakest. (Rule 4)



Maximum proportion of bonded area now contributes to strength. (Rule 2) Adhesive is now stressed in the direction of its maximum strength. (Rule 3) Stress is now minimized in the direction the adhesive is weakest. (Rule 4)

Production line application of adhesives

It is as important to choose the right method of applying the adhesive as it is to select the proper adhesive.

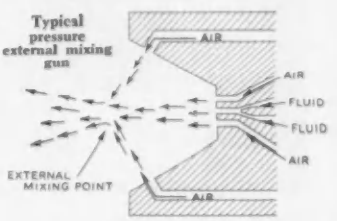
A straight-line manufacturing process with parts handled by a mechanical conveyor obviously is the most desirable setup. The adhesive is applied at the first stage, the adhesive film prepared for bonding in the second stage, and the application of pressure, if necessary, in the third stage.

The methods of application most suitable to straight-line production are spraying and roller coating.

1. Spray coating

Spray coating offers the same advantages for adhesives as for paints. Adhesives ranging from water-thin resins to viscous synthetic rubber products and even abrasive-filled materials are applied in this manner.

Some adhesives and coatings may be applied as an even, perfectly smooth film. Materials of this type should be sprayed with a pressure type (not suction) external mixing gun. The intermediate nozzle or fluid opening sizes ordinarily used for paints will control the amount of fluid ejected into the air stream, so that all of the fluid is "atomized." Fast-drying adhesives, particularly those based on synthetic rubber, cannot be applied with



paint smoothness, but will spray with uniformity in almost any thickness desired. Selection of the correct air gap and fluid opening is important. Large fluid openings are better with viscous adhesives, but only if air pressure can be increased proportionately. With synthetic rubber type adhesives, higher air pressure is usually needed for breakup of the fluid stream.

Adhesives of this type can be improved by lowering the viscosity by dilution, using the recommended solvent. In using an adhesive that has been severely thinned, it must be remembered that solids content is low.

In many applications, the speed and economy offered by automatic spray equipment will quickly repay the investment required. Where the nature of the work requires hand spraying, some of the more important points are: hold the gun no more than 7" or 8" from the work; "trigger" the gun at the end of each pass rather than attempt to operate the gun continuously; hold the gun at right angles to the work to insure uniform film thickness.

2. Roller coating

Where continuous production runs of sheets of one thickness are involved, roller coating is fast and economical.

If properly compounded, most water base adhesives will roller coat on standard equipment.

Fast-drying adhesives of the synthetic rubber type require slight machine modification and a different technique. Most solvents for adhesives will attack rubber or plastics so that metal rolls must be used throughout. Synthetic rubber adhesives tend to adhere to the applicator roll and will not apply uniformly from a smooth-surfaced roll. To remedy this, the roll should contain "reservoirs" for the adhesive and enough surface irregularity to prevent suction. This may take the form of grooves at right angles to the roll axis or small cups engraved on the roll. In either case, the area between the grooves or the cups should be cross-hatched or broken up in some way. The amount of adhesive applied is determined by the depth of the machined "reservoirs" and their spacing.

While the coater is in use, the adhesive should be prevented from losing solvent by evaporation, which increases viscosity. To do this, the adhesive should be fed to the pan continuously at the used rate. The pan should be covered or the adhesive stirred in the pan for uniform feed to the take-up roll. Production should be as nearly continuous as possible.

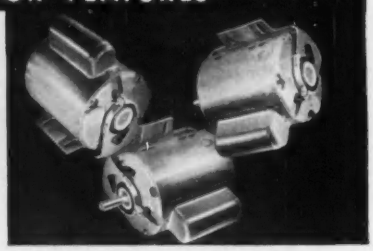
For more information on adhesives—and design problems involving adhesives—write for a copy of "Armstrong Adhesives, Coatings, and Sealers." Armstrong Cork Company, Industrial Division, 8002 Irvin St., Lancaster, Pa.

All these smaller, lighter G-E motors

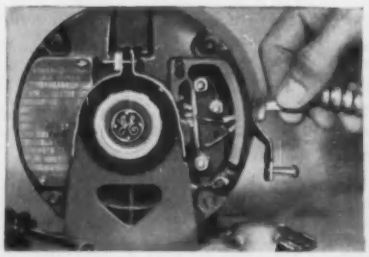
ONLY G.E. OFFERS ALL THESE SUPERIOR FEATURES

SMALLER, LIGHTER DESIGN—as much as 40% smaller and 50% lighter—speeds assembly and cuts product shipping weight.

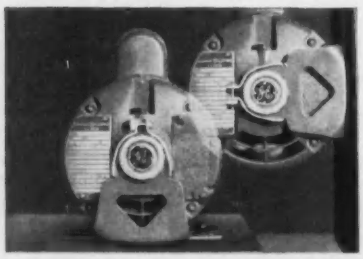
MYLAR* INSULATION (right): 35 times the moisture resistance, 8 times the dielectric strength of paper insulation (left).



ALL-ANGLE OPERATION—lubrication is sure and protective when mounted in any position; no need for costly specials.



EASY CONNECTION—terminals are close to cover plate; speed-nut welded inside shell for fast connection from outside.



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DOUBLE LUBRICATION LIFE—50% more oil capacity and more efficient oil retention system cut G-E motor maintenance.

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Act today to cut YOUR costs on material, assembly, shipping!

You have the opportunity to save *now* with smaller, lighter fractional-hp motors. General Electric, which pioneered these advanced motors three years ago, now offers prompt delivery on more than 850 *basic* models—including the right motors for *your* products.

IMPROVED PRODUCTS—plus savings in material, assembly, and shipping—await your conversion to these "years-ahead" G-E motors. For example: a compressor builder cut over-all manufacturing costs 25%. A pump manufacturer doubled sales of his streamlined product. A third manufacturer has reduced his shipping costs by 35%.

PROVED PERFORMANCE of smaller, lighter G-E motors on over 4,000,000 products demonstrates the superiority of the features listed at left.

TO HELP YOU realize *all* these benefits, G.E. offers application aid from engineers who have helped apply these advanced motors to all types of products.

WHY WAIT? Prompt delivery of the G-E motors you need can help you carry out a quality-boosting, cost-cutting program on your products without delay. For full information, including case histories of actual cost savings with G-E fhp motors, contact your G-E Apparatus Sales Office today. Or write Section 702-23, General Electric Co., Schenectady, N. Y.

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Mallory Engineered Materials Selection Can Cut Your Contact Costs

Mallory Contact Engineering Offers Five Ways To Improve Economy

1. **The most effective contact material** from the extensive line developed by Mallory. More economical alloys often can satisfy *actual* service conditions.
2. **The most economical contact design** . . . for your purchasing, production and product needs.
3. **The most economical backing material** . . . from a group of Mallory alloys developed for this use.
4. **The most economical backing member design** . . . in relation to contact and product design requirements.
5. **The most economical method of assembly** of contact and backing member.

By coordinating *all* these important elements of contact design, Mallory can help you put into effect a long-range plan for cutting contact cost and assuring peak performance.

CHOOSING the contact material that exactly matches your product requirements can often reduce over-all contact costs. For example, designers of a circuit breaker selected one of the Mallory Elkonite® materials for the contacts. This is a superior material for heavy-duty service, with high resistance to sticking and arc erosion.

Mallory engineers examined the product requirements . . . and recommended a change in materials. They found another ELKONITE, a higher silver content material, would give excellent performance on this medium-duty application. And because this material involved fewer manufacturing operations, the contacts could be made at lower cost. The customer's savings amounted to $10.16 per thousand . . . a total of over $8,000!

Mallory engineers are especially well qualified to help you get the best economy and performance in your contacts. They have a uniquely broad range of Mallory contact alloys from which to choose. And their extensive application experience is valuable in coordinating *all* phases of contact, backing member and assembly design to assure you of top value for your contact dollar. Write or call Mallory for a consultation on your particular application.

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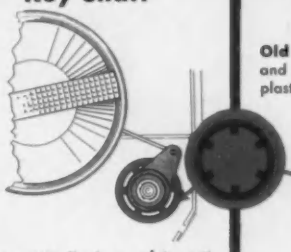
5 Waldes Truarc Rings simplify assembly, eliminate parts, bring big over-all savings to new design low-cost camera

Anscoflex II Camera

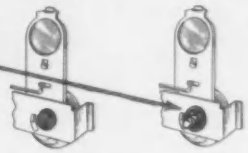
Key Shaft



Parts originally designed for self-locking Truarc ring (series 5105). Some cameras in the past had brass cup staked to the body. At times staking operation cracked the plastic, resulting in loss of expensive part.

Portrait and Filter Lens Knob Assemblies

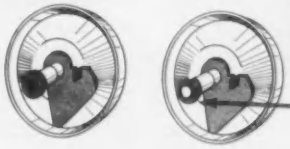
Old way: Knob with plastic shaft used washer and heat forming operation that flattened the plastic pin and locked the pivot in position.



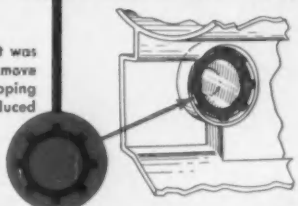
Truarc way: Molded plastic knob with pin is easily and quickly held by a Truarc self-locking ring (series 5105). No groove is necessary. Washer is eliminated and it is possible to remove ring if necessary without damage to knob.

Winding Knob

Old way: With screw and washer design, it was necessary to disassemble entire camera to remove screw which secured winding knob. Self-tapping screw sometimes failed to secure knob, produced excessive end play.



Truarc way: Truarc "E" ring (series 5133) allows removal of winding knob without major disassembly of camera, reducing repair time. Use of stacked rings and Truarc applicator saved $10.40 per M on labor. Material saving: $2.29 per M.

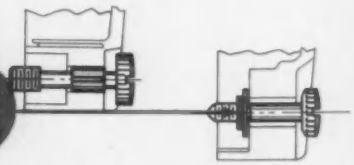


Rear Lens

Parts originally designed for self-locking Truarc ring (series 5005) Some cameras in the past had glass element secured by heat forming tabs from plastic body. Loose or chipped elements resulted in loss of both parts.

Flash-Gun Case Assembly

Old way: In the original design a sleeve was wrapped around neck of screw and pressed into hole of plastic cover. Close working areas made assembly difficult and required extra operation to lock ring into place.



Truarc way: Series 5133 E-Ring snaps onto unthreaded shank of screw quickly, needs no special groove. Labor saving $7.06/M.

Ansco, Binghamton, N. Y., uses the latest technical advances in construction to produce an economical, easy-to-use reflex camera. 5 Waldes Truarc Rings are used in this new design to save material and labor costs, eliminate parts, simplify assembly and reduce rejects.

Whatever you make, there's a Waldes Truarc Retaining Ring designed to improve your product... to save you material, machining and labor costs. They're quick and easy to assemble and disassemble, and they do a better job of holding parts together. Truarc rings are precision engineered and precision made, quality controlled from raw material to finished ring.

36 functionally different types... as many as 97 different sizes within a type... 5 metal specifications and 14 different finishes. Truarc rings are available from 90 stocking points throughout the U. S. A. and Canada.

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PH-5231

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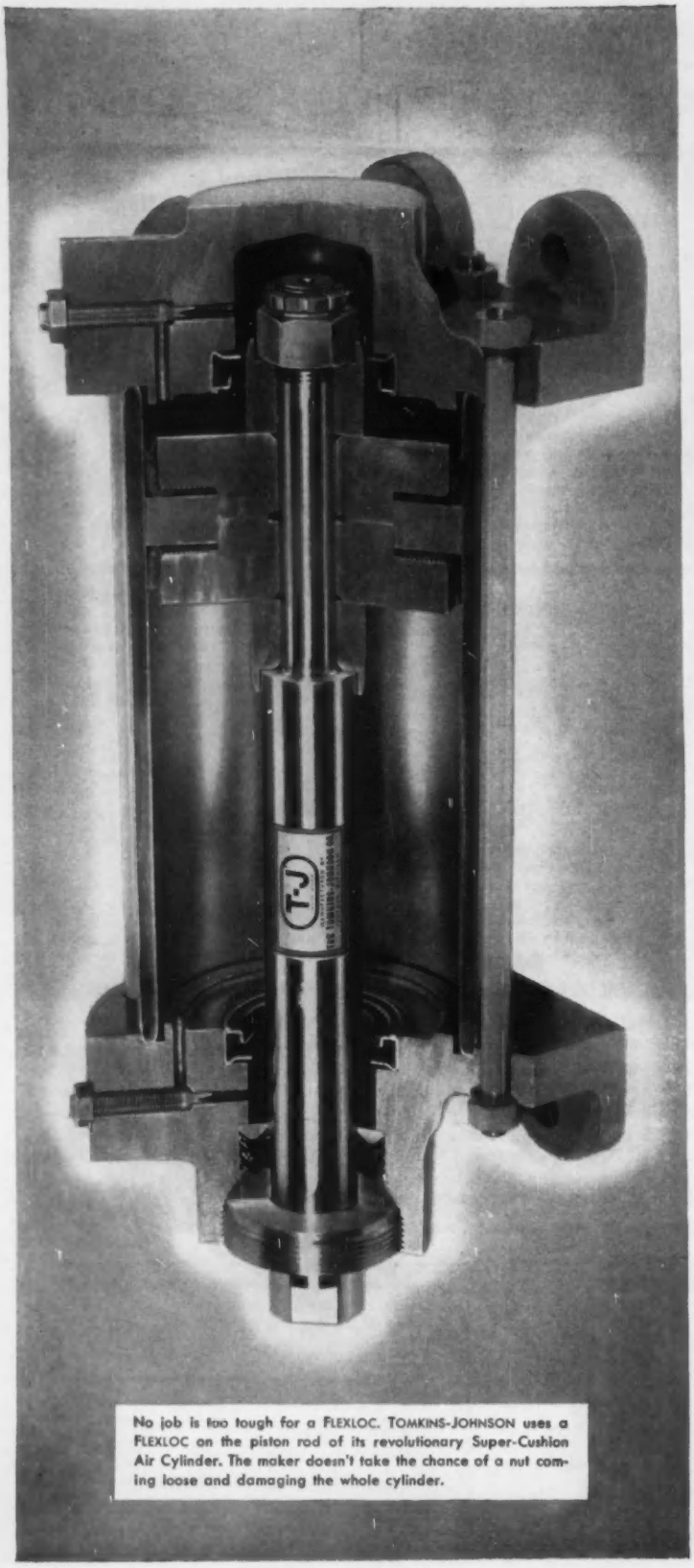
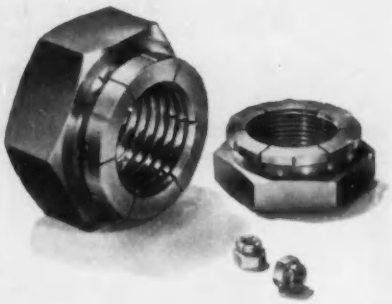


No job is too tough for a FLEXLOC. TOMKINS-JOHNSON uses a FLEXLOC on the piston rod of its revolutionary Super-Cushion Air Cylinder. The maker doesn't take the chance of a nut coming loose and damaging the whole cylinder.



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FLEXLOCs eliminate complicated, time-consuming methods of locking threaded fasteners. They offer simpler, faster application and safer, more dependable locking than plain nuts and lockwashers, castellated nuts and cotter pins, or nuts and jam nuts. And they won't work loose.

The reasons for all this are plain. FLEXLOCs are one piece—nothing to assemble, come apart, lose or forget. FLEXLOCs are all metal—have higher tensile than most other locknuts and are not affected by temperatures to 550°F. FLEXLOCs are both stop and locknuts—don't have to seat to lock, and stay put anywhere on a threaded member as soon as their locking threads are fully engaged.

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LOCKNUT DIVISION

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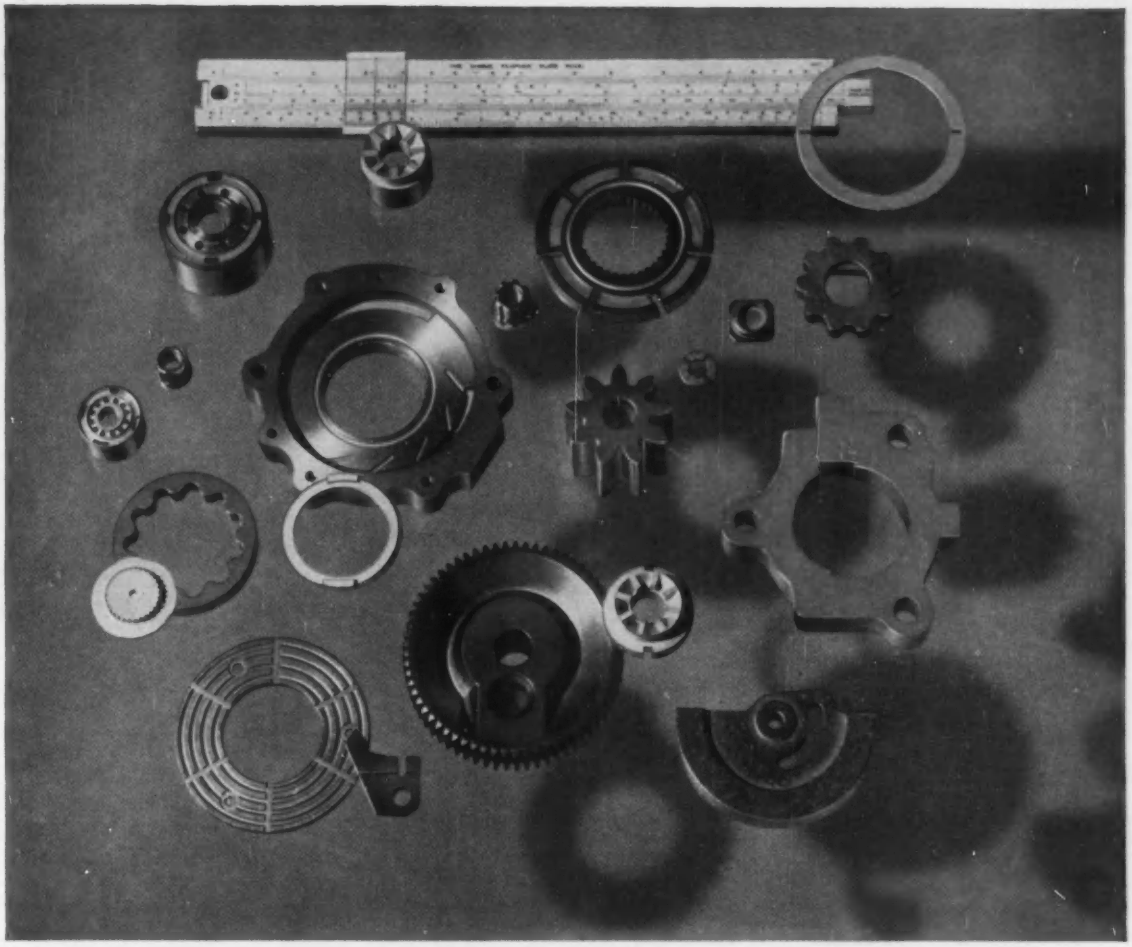

A look at your needs . . . through the eyes of our experiences

You are looking at a typical group of precision parts each of which is being produced in large quantities by Moraine Products from metal powder. When you note the wide variation in shapes and sizes, you will realize each part was designed for a specific application.

What may not be obvious is the fact that, when Moraine Products is asked to produce parts like these, each part is carefully weighed in these terms: What will it be asked to do for the end product of which it will become a component?

Because we purchase or manufacture—for our own use, in our own plant—parts made by stamping, screw machine, forging, cold-heading, molding, and casting, we are familiar with a wide range of processes commonly used in industry. Consequently, our judgment can be considered realistic when we recommend metal powder and powder metallurgy as the material and the process best suited for a specific part.

Other Moraine products include: Moraine power brakes — Delco hydraulic brake fluids, brake assemblies, master cylinders, wheel cylinders and parts—Moraine friction materials —porous metal parts—rolled bronze and bi-metal bushings—self-lubricating bearings, and automotive engine bearings.

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Division of General Motors, Dayton, Ohio

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The latest addition to Lukens' complete line of carbon, alloy and clad steels, this quenched and tempered alloy plate steel's unusual combination of properties suits it especially to application in pressure vessels, bridges, shipbuilding, construction machinery and general industrial equipment. On problems of design, selection, application and fabricating techniques, Lukens offers full technical assistance. If you would like further information on Lukens "T-1" steel, write today. Address: Manager, Marketing Service, 775 Lukens Building, Lukens Steel Company, Coatesville, Pennsylvania.

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Allis-Chalmers offers an extensive line of manual and magnetic control to meet every condition of motor operation. Control functions, varying with specific job requirements, include full or reduced voltage starting, acceleration, speed control, reversing or non-reversing, and dynamic braking.

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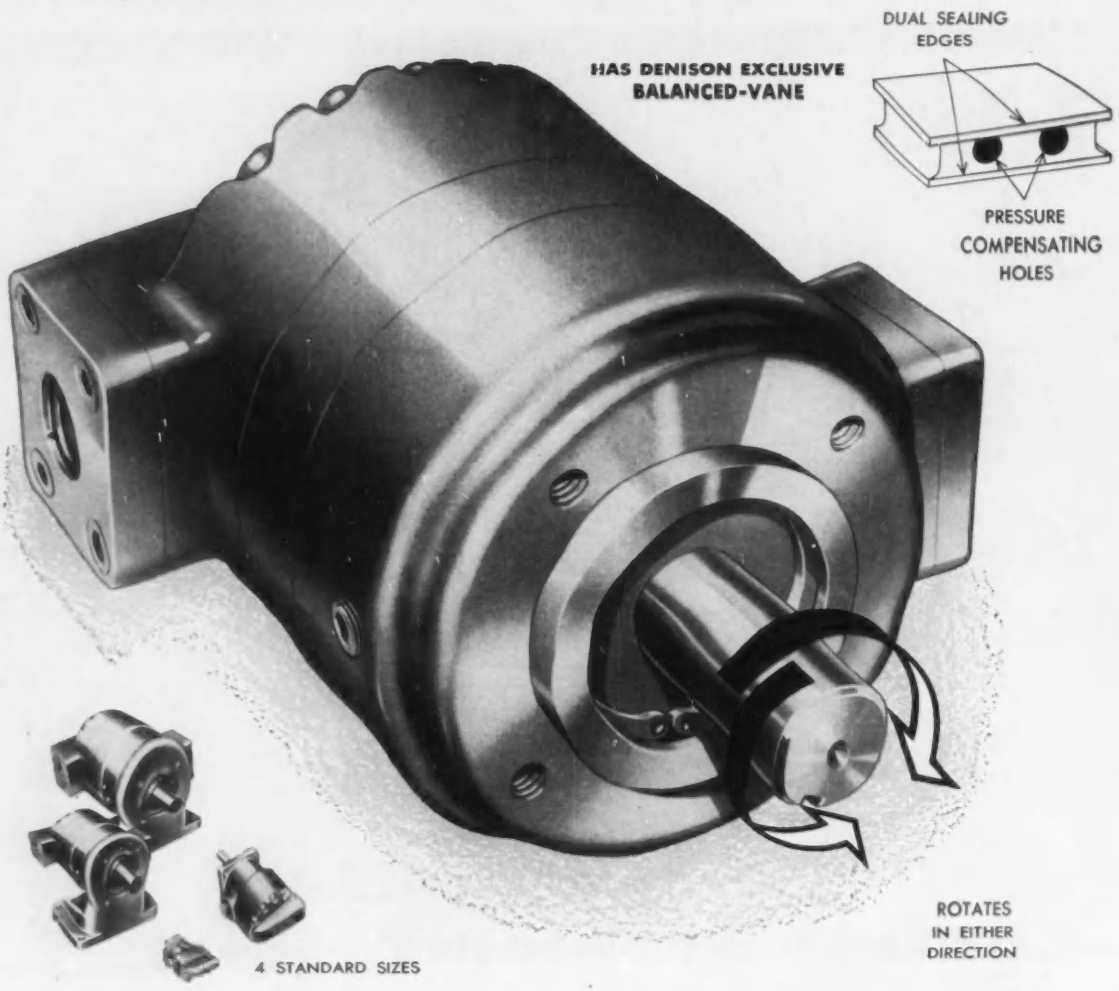
Built into all Allis-Chalmers control is the type and degree of protection dictated by the application. Controls are available in general purpose and special cabinet, including water-tight, dust-tight and explosion-proof enclosures. A-4516

For complete information on any specific control problem, call your nearby Allis-Chalmers representative or write Allis-Chalmers, Milwaukee 1, Wis.

ALLIS-CHALMERS



for continuous 2000 psi service...

Vane type Denison hydraulic single stage, Pump/Motor

IT'S A PUMP—high delivery in a small, compact package . . . a continuous 2000 psi pump.

IT'S A MOTOR—high stalled torque up to 257 pound-inches per 100 psi. Takes high shock pressures without danger.

EXCLUSIVE—Denison *Radially Balanced* Vane; *Cuts wear* between cam ring and vane; *Increases efficiency* with dual sealing edges; *Reduces pulsation* by radial pumping action of vanes.

SIMPLIFIES INVENTORY

No need to stock separate pumps and motors. Runs as a pump or motor without alterations. Range of capacities in each size through interchangeable cam rings.

EITHER DIRECTION—Operates efficiently as a pump or motor without change in piping. Minimum internal friction in either direction because of greatly reduced contact pressure between vanes and cam ring.

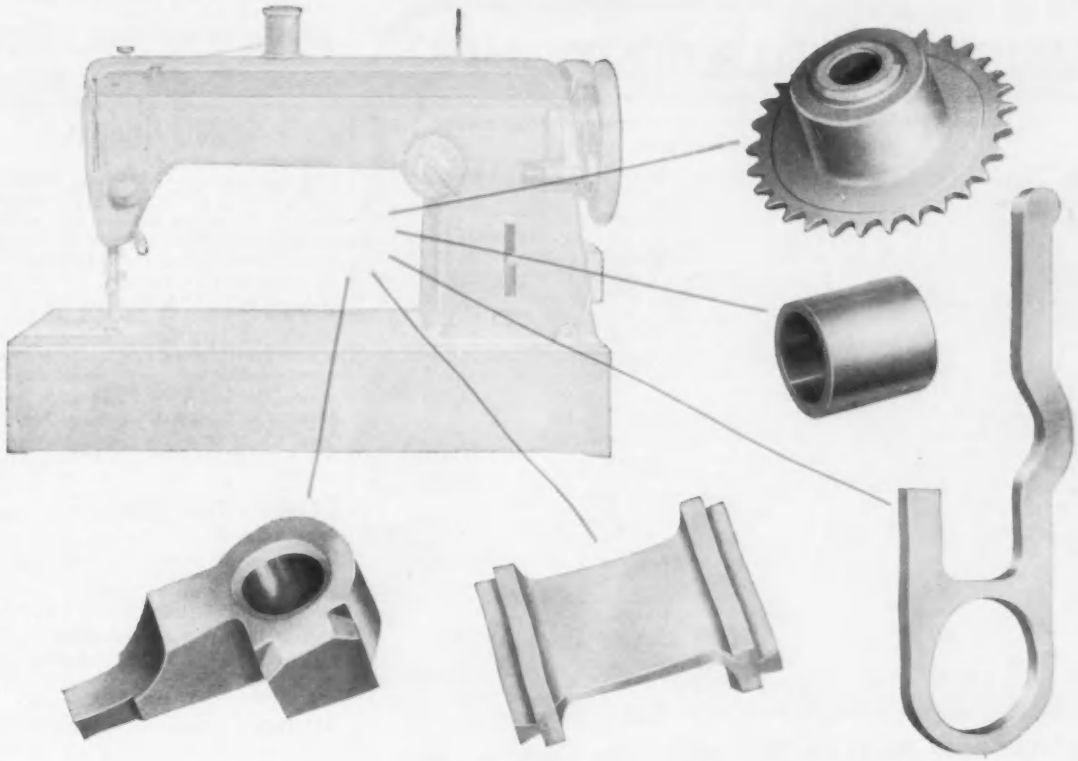
STANDARD SIZES—as a pump, Range of delivery 2.5 to 77 gallons per minute at 2000 psi.
As a motor, Horsepower output 1 to 103 hp at 2000 psi.

MORE INFORMATION—Send for Bulletin P-5-A giving complete specifications. Write . . .

THE DENISON ENGINEERING COMPANY
1160 Dublin Road • Columbus 16, Ohio
A Subsidiary of American Brake Shoe Co.

DENISON HydrOILics
HYDRAULIC PRESSES • PUMPS • MOTORS • CONTROLS

IN POWDER METALLURGY . . . IT'S AMPLEX



Switching to OILITE® helps

Make this Manufacturer Competitive

Price competition and rising production costs caused one sewing machine manufacturer to re-examine his component parts to determine how costs could be lowered while maintaining high quality standards.

Super OILITE and Steel OILITE provided the answer. Many parts, including gears, eccentrics and sprockets, were redesigned for production in these high-strength materials. Formed in automatic presses in seconds, these OILITE parts reduced costs substantially by eliminating costly machining operations . . . and high quality is maintained.

The conversion provided another benefit. Certain parts were designed to take advantage of the self-lubricating qualities available in some OILITE materials.

Let Amplex help you with your parts problems. The Chrysler-Amplex engineering facilities, unmatched in the powder metal industry, are ready to serve you. Call or write today.

CHRYSLER AMPLEX PRODUCTS

OILITE Bearings
Permanent Metal Filters
Finished Machine Parts
Friction Units

IT'S NEW! IT'S FREE!

First complete information on powder metal bearings, finished machine parts, filters and special parts. 48 pgs. Write today for OILITE Engineering Manual E-55.

OILITE — Only Chrysler makes OILITE

CHRYSLER CORPORATION • AMPLEX DIVISION

Dept. F-2 Detroit 31, Michigan • Overseas Distribution—Chrysler Export

MORE EFFICIENT DESIGN, IMPORTANT SAVINGS, SIMPLIFIED ASSEMBLY, BETTER APPEARANCE

These are some of the many benefits reported by Design Engineers who have adopted TRU-LAY PUSH-PULLS for remote control operations on literally hundreds of products

Here are typical comments recently received from equipment manufacturers whose machines or implements are equipped with these accurate and dependable remote controls:

Saves Time, Labor and Material
"The use of your flexible Push-Pulls saves us a great deal of time, labor and material. The old linkages frequently required much planning in both engineering and shop which is not required now. On some of our equipment we use Push-Pulls from 10 to 30 feet in length. They operate clutch controls on the Main Power Unit, Feed Conveyors and Delivery Conveyors."

Greater Flexibility of Design
"The principal advantage of Tru-Lay Push-Pulls in our application is that they permit flexibility in locating the control valve in relation to the operator's position."

Cost Less to Install
"Tru-Lay Push-Pulls are easier and less expensive to install than linkages for remote control of power take-off, brake and clutch. Better appearance, too."

Simple and Neat
"For several models of farm tractors, we selected your controls for their simplicity and neatness of application as governor controls."

Solution to Tough Problem
"Can be installed where straight rods are impossible . . . for Remote Control of transmissions, brakes and clutches."

Eliminates Maintenance
"Simple operation and elimination of maintenance problem are the major advantages in using your Push-Pulls."

Reduces Number of Parts
"Your Push-Pulls have eliminated links, radius rods and other lost-motion devices for remote control of hydraulic valves."

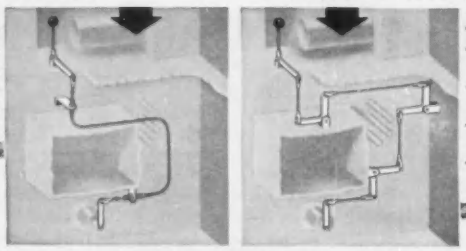
Provide ACCURATE Control
"Tru-Lay Push-Pull control cables provide minimum back-lash, even in installations up to 30 feet in length, because the cable is designed to close tolerances with minimum drag and lost motion."

• • •

TRU-LAY PUSH-PULLS are "Solid as a rod but *Flexible* as a wire rope." This flexibility makes it possible to snake around obstructions . . . permits the ideal arrangement of all elements of remote controls.

***Advantages** of Tru-Lay Push-Pull flexibility and simplicity are pictured below—*

TRU-LAY PUSH-PULL — **MECHANICAL LINKAGES**



Construction Equipment and **Farm Implements** provide good examples of the wide-spread use of these accurate, simple and dependable Push-Pulls. On Power Shovels, Winches, Graders, Road Oilers, Dump Trucks, Snow Plows, Engine-driven Pumps, Crushers, Tractors, Combines, Corn Pickers, Corn Row Sprayers, Corn Detasslers, Orchard Sprayers, Power-driven Tree Trimmers, Tobacco Picking Machines and others . . .

TRU-LAY PUSH-PULLS are operating unfailingly for the remote control of Hydraulic and Air Valves, Brakes, Clutches, Transmissions, Throttles, Chokes, Governors, Power Take-Offs, Spray Nozzles, Vent Directional Fins and on many other applications.

ACCO *Our DATA FILE will answer all further questions*

AUTOMOTIVE and AIRCRAFT DIVISION
AMERICAN CHAIN & CABLE

601E Stephenson Bldg., Detroit 2
2216E South Garfield Ave., Los Angeles 22 • 929E Connecticut Ave., Bridgeport 2, Conn.

TRADE MARK

(Advertisement)

There is No Worry about Failures or Maintenance Costs with TRU-LAY Push-Pull Remote Controls

Long Life is a matter of record. We have never heard of a Tru-Lay Flexible Push-Pull Control wearing out in normal service. Failures, that sometimes harass users of more complex controls, are eliminated by the use of these simple, positive-action controls.

Dependable Operation of these controls is a certainty, even under the most adverse conditions . . . HOT as jet engines (note: Tru-Lay Push-Pulls are actually performing on hot jet applications) . . . COLD to 70° F below zero . . . SOAKIN' WET . . . ABRASIVE . . . or just plain TOUGH.

Freedom from Trouble is assured because of such features as . . . full protection of the inner, working member by the tough flexible conduit . . . lubrication of the inner, working member *for life* during assembly . . . seals that keep moisture, dust and other foreign matter out of the unit . . . cold swaging of fittings that makes them integral parts of the control unit.

Accuracy is inherent in the basic design of Tru-Lay Push-Pulls. They are precision products, not gadgets.

Capacity ranges from light jobs up to jobs of 1,000 lbs. input. These Push-Pulls will handle jobs 150 feet or more from the control point.

"Solid as a rod, Flexible as a wire rope" aptly describes Tru-Lay Push-Pull Controls. This flexibility provides positive, remote action whether anchorages are fixed or movable . . . it damps out noise and vibration . . . it greatly simplifies installation of controls by reducing the number of working parts and by making it possible to snake around obstructions.

Adaptability to all sorts of mechanical situations explains, in large measure, the wide-spread application of Tru-Lay Push-Pulls. Standard anchorages, fittings and heads have been designed that meet requirements on approximately 80% of the installations. Simple modifications of these standards, or minor changes in your own design, cover almost every special situation. Our engineers have the know-how on such matters, and will work with you.

For Further Information—The DATA FILE pictured at the left contains six booklets and bulletins that will answer any further questions you may have about this versatile and dependable tool. It is quite likely that this material will point the way to a simplified solution of your remote control design problems. Write for a copy.

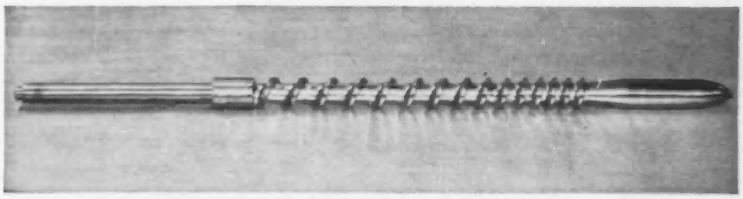
DOW

Plastiatrics

DOW'S CLINICAL APPROACH TO HEALTHY PLASTICS APPLICATION

PLASTIATRICS HELPS YOU CHOOSE AND USE PLASTICS CORRECTLY

Are you getting the most out of the plastics you need? Do you have the best or the latest for your money? Are you satisfied that plastics are right for the job? That's where *Plastiatrics* comes in . . . to provide a continuous study, analysis and treatment of plastics . . . to understand, prevent or cure plastics problems. Dow, which produces polystyrene under the trade name Styron®, conducts studies in many fields of plastics. For example, continuing studies are undertaken on extrusion. These are of significance to engineers and plastics molders.



DOW'S STUDIES ON IMPROVED SCREW AND TORPEDO DESIGN HELP MAKE POLYSTYRENE EXTRUSION A MORE EXACT SCIENCE

Studies for the development of a better screw and torpedo from polystyrene extrusion are good examples of Plastiatrics at work. Manufacturers using machines equipped with a single flight screw and torpedo arrangement like this one shown here can profitably extrude high-quality polystyrene and get uniformly good results. One thing that was found in working out the details of this better screw was that single flight eliminates blocking in one channel and flowing in another, a problem of the double flight screw that more often than not produces wide variations in product output.

Further studies of the torpedo have led to extensive findings, relative to the use of the torpedo screw, which are available by simply writing Dow.

Standard pressure gage studies another area of Plastiatrics development

Extensive Plastiatrics studies in extrusion have been made on the proper design of dies, take-off equipment and cooling problems. Dow engineers, together with plastics manufacturers, also developed a method for determining optimum pressure and for providing reproducible extrusion performance using a standard gage.

Write for free bulletins

Detailed results of Dow's studies on extrusion are available to you, as they are on all work done in Plastiatrics. For further information, write today . . . Dow Plastics Sales Department **PL-456G1,** THE DOW CHEMICAL COMPANY, Midland, Michigan.

DOW POLYSTYRENE FORMULATIONS:

- Styron® 666 . . . Dow general-purpose polystyrene.
- Styron 688 . . . for controlled flow and controlled pressure distribution in the mold cavity.
- Styron 777 . . . for medium-impact strength.
- Styron 475 . . . for high-impact strength and high elongation.
- Styron 475 sheet . . . for vacuum or pressure forming.
- Styron 480 . . . for extra-high-impact strength.
- Styron 700 . . . for high heat resistance.
- Styron 683 . . . for medium-high heat resistance.

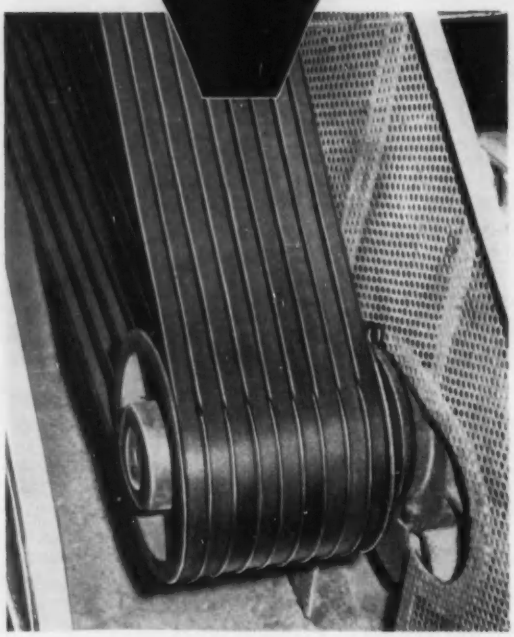
you can depend on DOW PLASTICS

DOW

Now... new flexibility... economy in machinery design made possible by

PREMIUM V BELTS *reinforced with* DACRON

REG U S PAT OFF
POLYESTER FIBER



Greater power-handling capacity... lower drive costs... easier matching with this stronger, more stable reinforcement!

To meet today's demand for smaller, more compact, more economical v-belt drives, manufacturers have developed premium v-belts reinforced with "Dacron"* polyester fiber that:

1. Lower drive cost.
2. Save valuable space.
3. Transmit up to 40% more horsepower, depending on belt construction.
4. Withstand greater shock loading.
5. Have longer flex life.
6. Are more stable.
7. Have less stretch.
8. Require less maintenance.

"Dacron" in v-belts is approximately 40% stronger than conventional fibers. It is highly resilient—"gives" under high impact—but resists stretch and compression. And the low moisture regain of "Dacron"—only 0.4%—assures dimensional stability to changes in humidity.

Because these new high-strength, low-stretch v-belts permit use of fewer belts and smaller sheaves, they are more economical to install and to maintain.

For your next drive, consider the advantages of premium v-belts made with "Dacron". They combine the unique properties of "Dacron" polyester fiber made by Du Pont and the highest skills of leading manufacturers who make the belts. E. I. du Pont de Nemours & Co. (Inc.), Textile Fibers Dept., Wilmington 98, Delaware.

*"Dacron" is Du Pont's registered trademark for its polyester fiber.

COST COMPARISON

		Width of Sheave (Inches)	Cost (Dollars)
STANDARD BELTS (Total Rated Capacity 45.5 HP)			
Motor Sheave	10" p.d., 5C groove	5.375	38.68
Mill Sheave	20" p.d., 5C groove	5.375	64.08
V-Belts	5 standard C 144 "Matched Belts"		48.00
			150.76
PREMIUM BELTS Reinforced with "Dacron" (Total Rated Capacity 50.4 HP)			
Motor Sheave	10" p.d., 4C groove	4.375	32.62
Mill Sheave	20" p.d., 4C groove	4.375	54.03
V-Belts	4 premium C 144 "Matched Belts"		52.72
			139.37

DU PONT
REG. U.S. PAT. OFF.
BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

Want prolonged paint adherence?

Weirzin

ELECTROLYTIC ZINC-COATED SHEET

How to paint, enamel, lacquer or lithograph metal parts is often a perplexing problem. Poor adherence means dissatisfied customers.

Weirzin has a simple solution, proved highly satisfactory, in a tight malleable zinc coating that is *actually part of the steel*. The coat remains intact even under extreme temperature and humidity. What's more, neither punching nor forming nor deep drawing can rupture the even deposit. Thus underfilm corrosion cannot form and, as a result, paint does not crack, chip or flake.

This electrolytic zinc-coated steel—with or without chemical treatment—is available in coils, in cut lengths, in all regular widths and gauges. Find out how easily leading manufacturers satisfy their customers with this exceptional product. Phone or write now.

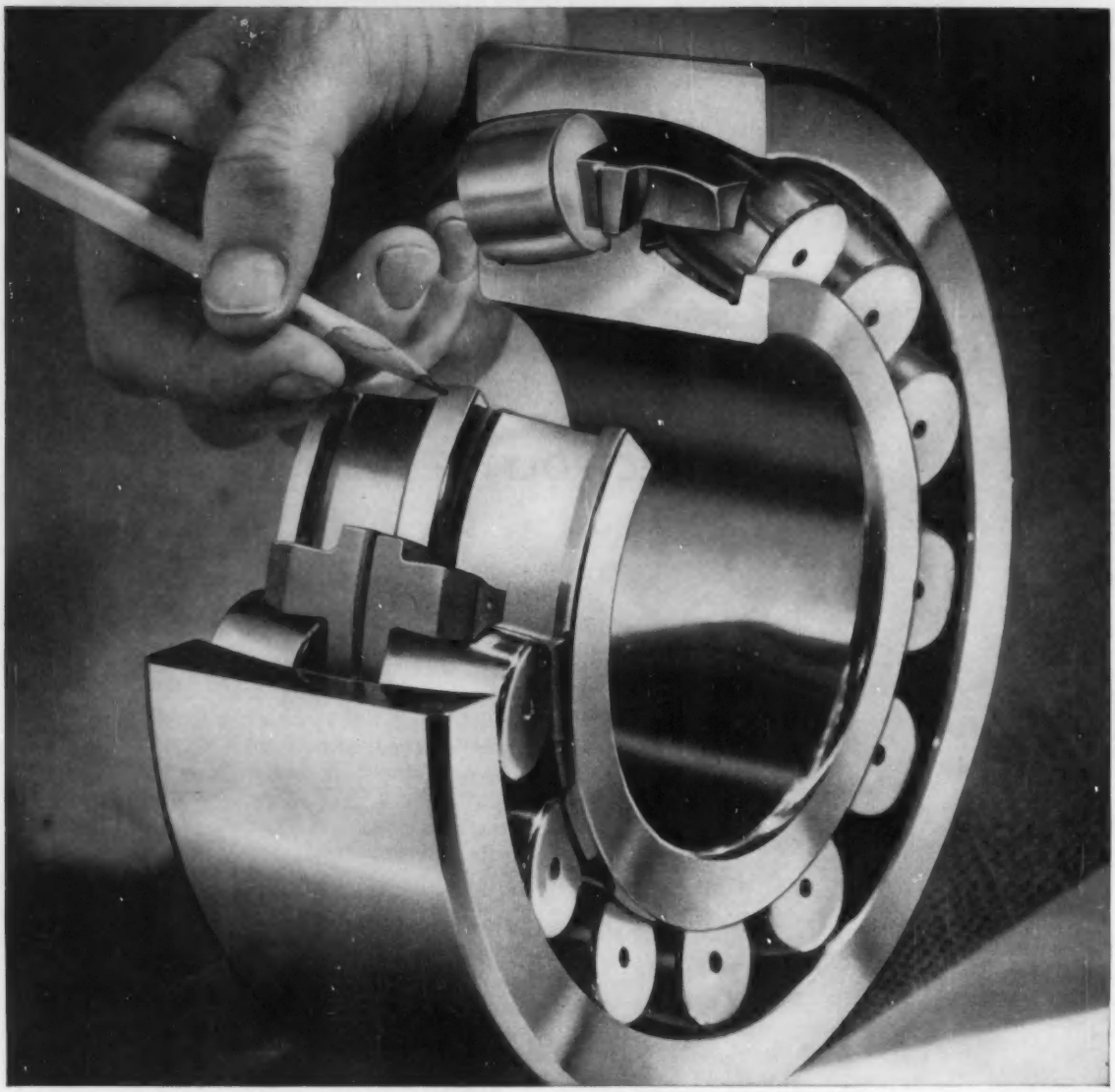
WEIRTON STEEL COMPANY

Weirton, West Virginia

NATIONAL STEEL CORPORATION

WEIRTON STEEL COMPANY

TORRINGTON *SPHERICAL ROLLER* BEARINGS



"This flange guides the rollers to peak performance!"

The center flange on the inner raceway of the TORRINGTON Spherical Roller Bearing positions the rollers to handle thrust loads. This accurate positioning also assures radial stability of the rollers under heavy loads—even at continuous high speeds and under conditions of misalignment.

This superior design feature is only one of many advantages you get when you specify TORRINGTON. For example, you get the service of TORRINGTON'S experienced engineers, who will help you with design and maintenance problems—or design custom bearings for special applications.

For long, low-maintenance service in heavy-duty applications, order TORRINGTON Spherical Roller Bearings. They're available from stock with either straight or tapered bore, for shaft or adapter mounting.

THE TORRINGTON COMPANY
South Bend 21, Ind. • Torrington, Conn
District offices and distributors in principal cities of United States and Canada

90th ANNIVERSARY 1866-1956

TORRINGTON BEARINGS

Spherical Roller • Tapered Roller • Cylindrical Roller Needle • Ball • Needle Rollers

they grip tight...seal tight
—they're made of

CRUCIBLE
stainless steel cold heading wire

These *Tuff-Tite** fasteners, made by Townsend Company, New Brighton, Pa., have a neoprene washer preassembled into the head. They stop leaks... hold tight even where there's severe vibration... seal out moisture effectively.

Of course high speed production of these fasteners, like other types of screws, bolts, rivets and pins, demands cold heading wire with optimum workability. That means wire that's structurally sound and metallurgically uniform... with sufficient ductility to make forming easy... and with good tensile strength.

Crucible stainless steel cold heading wire has all these qualities — *plus* exceptional corrosion-resistance. That's why Crucible Types 305 and 410 stainless are used for the new *Tuff-Tite* fasteners, as well as for many other types of fasteners.

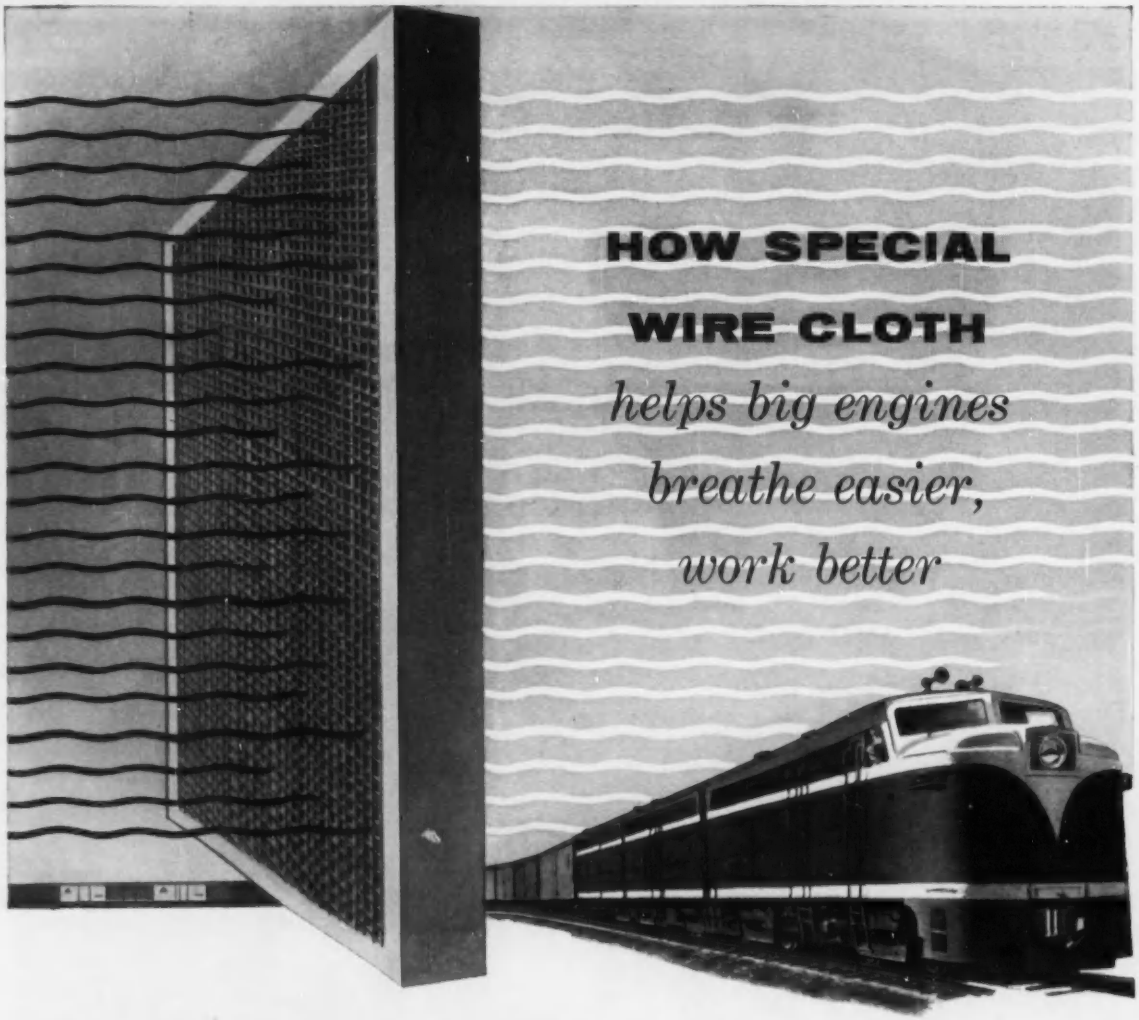
Crucible will fill your stainless cold heading wire needs quickly and efficiently... in the grade and size that best fits your application. Talk over your production requirements with your Crucible representative soon. *Crucible Steel Company of America, The Oliver Building, Mellon Square, Pittsburgh 22, Pa.*

*Trademark

Write now for your free copy of Crucible's new 32-page booklet on Rezistal stainless steel wire.

CRUCIBLE first name in special purpose steels

Crucible Steel Company of America



HOW SPECIAL WIRE CLOTH *helps big engines breathe easier, work better*

● Keeping harmful grit and dirt out of the lungs of big engines, like locomotive diesels, is no small problem. Determined to do the job better than ever before, a leading filter manufacturer turned to the *Reynolds Wire Division* of National-Standard for a special wire cloth that would trap all the dirt and still let such engines breathe the terrific volume of air they need.

No simple assignment this, for it took months of concentrated development work—not only to develop the *kind* of wire cloth that would do the job, but also to find out *how best* to produce it. It had to be slit into narrow widths, with special lock wires to prevent raveling. It had to withstand a patented method of severe forming and crimping without compacting. And despite the special construction and narrow slitting, it had to be furnished in extra large continuous rolls. All were tough problems to lick!

The *ability* to lick a tough problem in wire cloth is one thing. The *willingness* to do it is quite another. You get *both* at Reynolds Wire. But, problem or no problem, short orders or large volume production, you too will find it pays to turn to Reynolds. Try us and see.

NS NATIONAL-STANDARD Company NILES, MICHIGAN

NATIONAL-STANDARD COMPANY • NILES, MICHIGAN
Tire Wire, Stainless, Fabricated Braids and Tape
ATHENIA STEEL DIVISION • CLIFTON, N. J.
Flat, High Carbon, Cold Rolled Spring Steel
REYNOLDS WIRE DIVISION • DIXON, ILLINOIS
Industrial Wire Cloth
WAGNER LITHO MACHINERY DIVISION • JERSEY CITY, N. J.
Special Machinery for Metal Decorating
WORCESTER WIRE WORKS DIVISION • WORCESTER, MASS.
Round and Shaped Steel Wire, Small Sizes

Trepans and bores 32-foot gun barrels—TIMKEN® bearings keep huge spindle accurate

THIS Baldwin-Lima-Hamilton NILES A36B boring lathe has a finished weight of 235,680 lbs. and an overall length of 90 feet. It took one year to build and was specifically made to trepan and bore gun barrels as long as 32 feet. To give its huge spindle high accuracy and stability—despite heavy radial and thrust loads and speeds up to 1000 R.P.M.—the spindle was mounted on Timken® tapered roller bearings.

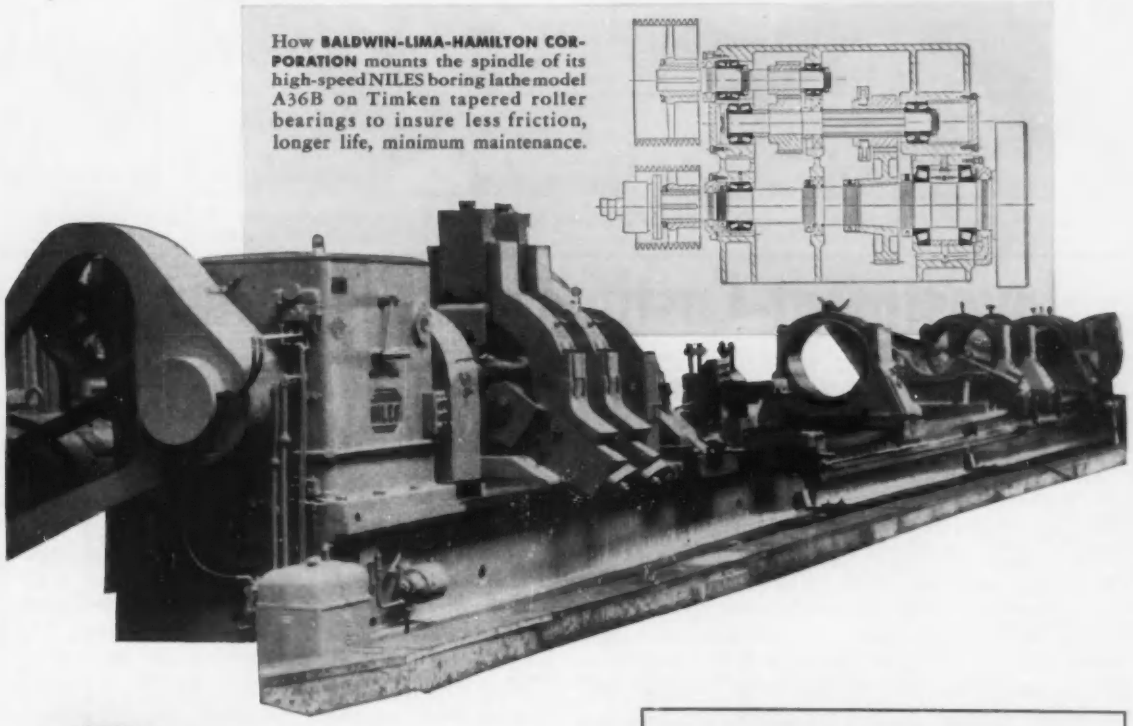
Timken bearings are tapered in construction to take the heavy radial *and* thrust loads this huge spindle gets. Full line contact between rollers and races provides maximum capacity. They maintain spindle precision and accurate gear mesh.

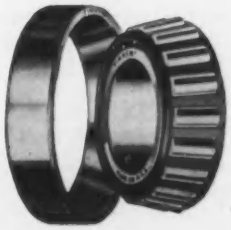
Timken bearings reduce wear because they practically eliminate friction. That's because they're designed by geometrical law to have true rolling motion and made with extreme accuracy so they live up to their design. And they're made of steel we make ourselves: we're the only American bearing maker who takes this extra quality precaution.

Specify Timken bearings for the machinery you build or buy. Always look for the trade-mark "Timken" on every bearing. The Timken Roller Bearing Company, Canton 6, Ohio. Canadian plant: St. Thomas, Ont. Cable address: "TIMROSCO".

This symbol on a product means its bearings are the best.

How **BALDWIN-LIMA-HAMILTON CORPORATION** mounts the spindle of its high-speed NILES boring lathe model A36B on Timken tapered roller bearings to insure less friction, longer life, minimum maintenance.





TIMKEN

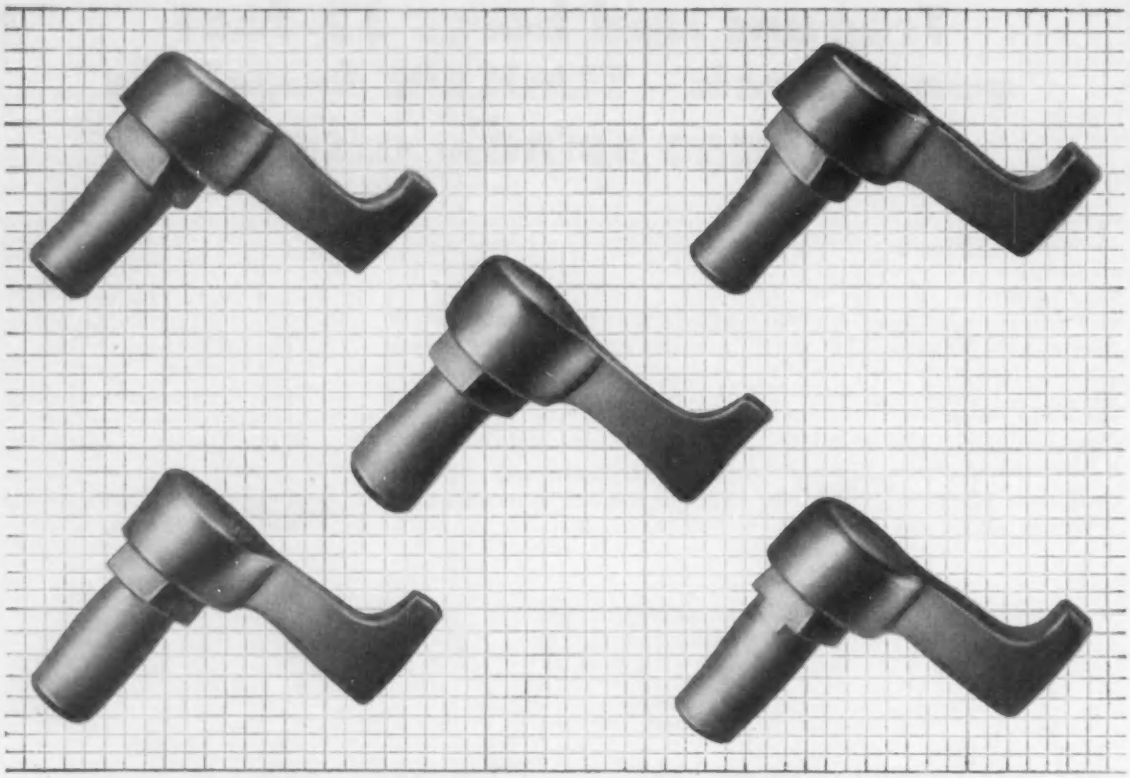
TRADE-MARK REG. U. S. PAT. OFF.

TAPERED ROLLER BEARINGS

DON'T MISS THE TIMKEN BEARING DISPLAY

You'll want to see The Timken Roller Bearing Company display at the Production Engineering Show, booths 425 and 426, September 6 through 16, Navy Pier, Chicago.

NOT JUST A BALL — NOT JUST A ROLLER — THE TIMKEN TAPERED ROLLER — BEARING TAKES RADIAL AND THRUST — LOADS OR ANY COMBINATION



Cam Segment—weighs less than an ounce, measures less than ½ inch.

Investment-Casting improves part ... eliminates hours of machining

HAYNES' investment-casting process made it possible to mass-produce a small intricately-shaped part in a hard, abrasion-resistant alloy. The part, a cam segment, is less than one-half inch long, and weighs only a fraction of an ounce. It is cast to size. Only one simple threading operation is required to prepare it for operation.

The cam segment is used in a control instrument and rides against a valve shaft under pressures up to 35 lb. per sq. inch. At one time it was cast from a relatively soft metal and machined to final dimensions. The machining time for each cam was several hours—an expensive operation. The performance of the part was unsatisfactory because the metal used was selected for ease of machining—and could not stand up under the abrasive conditions.

The investment-cast segments are now made of type 410 stainless steel. They have been used for over one million operations and still show no signs of wear.

The freedom to select alloys for performance, regardless of how difficult they may be to machine, is one of the big advantages of HAYNES' investment-casting method. Intricate shapes in hard metals can be cast close to size, eliminating many machining operations. For full details on the process, write to our general sales office in Kokomo, Indiana, or any of the district sales offices listed below.

HAYNES TRADE-MARK ALLOYS

HAYNES STELLITE COMPANY

A Division of Union Carbide and Carbon Corporation

UCC

General Offices and Works, Kokomo, Indiana

Sales Offices

Chicago • Cleveland • Detroit • Houston • Los Angeles • New York • San Francisco • Tulsa

"Haynes" is a registered trade-mark of Union Carbide and Carbon Corporation.

over 8,000 Different Cylinder SELECTIONS—

Miller

AIR AND HYDRAULIC

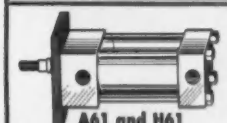
CYLINDERS AND BOOSTERS

"IN STOCK" for immediate delivery

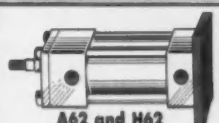
See Miller Bulletins A-105K (Air) and H-104K (Hydraulic) for Complete Dimensions and Engineering Data on these "in-stock" sizes and other Custom Miller Cylinders in bores up to 20" and strokes up to 22 feet.

"IN-STOCK" MODELS

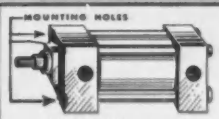
"A" Signifies Miller 200 psi Air Cylinders; "H", 2000 psi Hydraulic Cylinders. Interchangeable Mountings Are Shown In Red On Drawings.



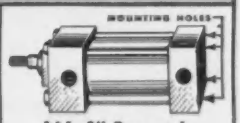
A61 and H61
Flange Mounting on Rod End
(A61 not available in 8" bore)



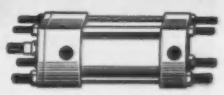
A62 and H62
Flange Mounting on Cap End
(A62 not available in 8" bore)



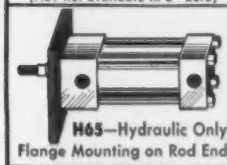
A63—8" Bore only
Flange Mounting on Rod End



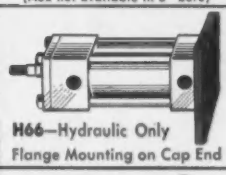
A64—8" Bore only
Flange Mounting on Cap End



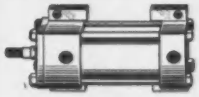
A50 & H50—Tie Rods not extended beyond nuts.
A51 & H51—Tie Rods extended both ends (shown).
A52 & H52—Tie Rods extended. Cap End only.
A53 & H53—Tie Rods Extended. Rod End only.
A54 & H54—Two Tie Rods extended at both ends.



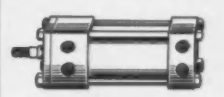
H65—Hydraulic Only
Flange Mounting on Rod End



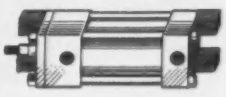
H66—Hydraulic Only
Flange Mounting on Cap End



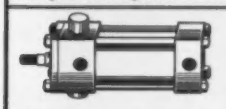
A72 and H72
Side Lug Mounting



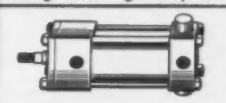
A74 and H74
Side Flush Mounting



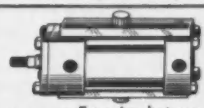
A77 and H77
Side or Foot Mounting



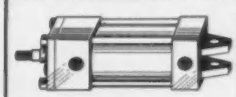
A81 and H81 Trunnion Mounting on Rod End



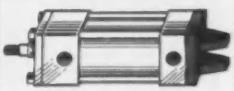
A82 and H82 Trunnion Mounting on Cap End



A83 and H83 Trunnion between Head and Cap
(one week delivery)



A84 and H84
Pivot Mounting



A86 and H86
Pivot Mounting

IN STOCK BORES in Inches

"IN-STOCK" STROKES (in Inches)

	BORES	ROD DIA.	ROD TURN DOWN & THREADS		1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
AIR	1½	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12									
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12									
	2	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	2½	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	3¼	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	4	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	5	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	6	1⅜"	1-14	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	8	1⅜"	1-14	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
HYDRAULIC	1½	⅝"	7/16-20	Cushioned			3	4	5	6	7	8	9	10	11	12									
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12									
	2	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	2½	1"	¾-16	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	3¼	1⅜"	1-14	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	4	1¾"	1¼-12	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
	5	2"	1½-12	Cushioned			3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36
				Non-Cush.	1	2	3	4	5	6	7	8	9	10	11	12	14	16	18	20	22	24	28	32	36

① "A" and "H" Models 82, 84 and 86 with strokes over 18" require stop tubes.

Column strength requires larger diameter piston rods for the following:

Air Cylinder Models A82, 84, and 86 with strokes inside area (1), when operated at 100 psi and over;

All hydraulic models with strokes inside area (2) and Models H82, 84, and 86 with strokes in area (4), when operated at 2000 psi and over;

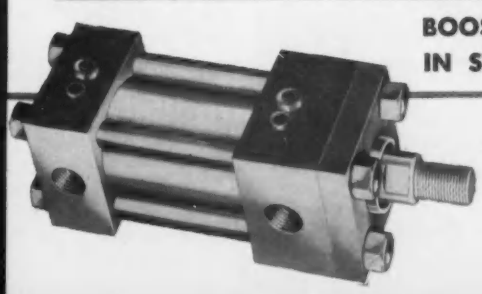
Models H82, 84 and 86 with strokes inside area (3), when operated at 1000 psi and over.

Depending upon Trunnion Pin location, "A" and "H" Models 83 with standard diameter piston rods can have longer strokes than Models 82, 84 and 86.

See Miller File #251 for oversize piston rod and stop tube requirements.

BOOSTERS IN STOCK

Immediate Delivery on the following Miller 25 to 1 Ratio Boosters (80 psi air input produces 2000 psi hydraulic oil output): Model B4, 5" bore, 1" dia. ram, 6" and 12" strokes; Reciprocating Booster Model DA77-RBA8, 5" bore, 1" dia. ram, 6" stroke. Also Booster Tanks, 5" dia., 6" and 10" heights.



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AIR & HYDRAULIC CYLINDERS • BOOSTERS • ACCUMULATORS
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New lock gates for New York State Barge Canal

While a vessel waits, the two huge new lock gates begin to swing open at Lock 17 on the New York State Barge Canal, at Little Falls, N. Y. Replacement of the old gates by these new ones, built by Alco Products, Inc., Schenectady, is part of the canal's extensive renovation program.

The new gates were fabricated of Mayari R high-strength, low-alloy steel. Mayari R was selected because of its superior corrosion resistance. Under marine atmospheric conditions, Mayari R has demonstrated twice the resistance to corrosion of copper steel and from five to six times that of carbon steel. Tests have also proved its superior lasting qualities under exposure to industrial atmospheres.

Weldability was another important factor in the fabrication of these gates, as each gate contained more than a mile of arc welding. Mayari R can be readily welded by all the usual methods, using shop procedures similar to those used with plain-carbon structural steels.

Mayari R has many other advantages, all of which are described and illustrated in detail in Catalog 353. Every design, production and purchasing man should have this informative book. To receive a copy, all you have to do is drop a line to the nearest Bethlehem sales office.

BETHLEHEM STEEL COMPANY, BETHLEHEM, PA.

On the Pacific Coast Bethlehem products are sold by Bethlehem Pacific Coast Steel Corporation. *Export Distributor:* Bethlehem Steel Export Corporation

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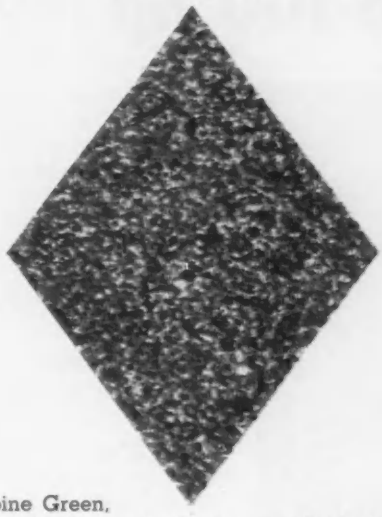
SINCE 1856

Imagine — a textured *and MULTICOLORED* finish — sprayed at *one* time, from *one* gun, in *one* coat that covers surface flaws and blemishes completely!



PLEXTONE Alpine Green, one of many standard pre-mixed colors available for prompt shipment. Also available in solid colors and in custom multicolors.

CAPSULE FACTS

WHAT IS COLOR-FLECKED PLEXTONE?

A completely new multicolored industrial finish in which colors exist separately. When sprayed, they form an interlacing color network of amazing beauty and durability.

CHARACTERISTICS

Lacquer base • Air dries approx. 30 minutes — dries hard 2 to 3 hours • Available in flat or semi-gloss • Exceptional hiding power — hides surface imperfections, covers porous materials • Remarkable abrasion resistance • Good chemical resistance • Does not stain • Can be scrubbed, even scoured • Quick and easy touch-up, without showing • Available in non-toxic grades • Bonds readily to primed wood, metals such as rust iron, steel, aluminum, brass, copper, zinc; also plastics, woven fabrics, wallboard, paper, cement, plaster, papier-mache forms.

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Manufacturers from coast to coast are using PLEXTONE to finish such products as Caskets • Displays • Furniture • Kitchen cabinets • Machinery • Office panels and partitions • Sewing machine tables • Silver chests • Signs • Store fixtures • Switch gear housings • Table lamps and shades • Toys • TV cabinets • Wallboard

PLEXTONE — CUTS FINISHING COSTS UP TO 35%

PLEXTONE often eliminates many pre-finishing steps on wood or metals. Usually no more than one coat of primer and one PLEXTONE coat are required! And PLEXTONE's texture hides wood knots, metal weld marks, flaws and blemishes.

PLEXTONE — AN UNBELIEVABLY RUGGED FINISH

PLEXTONE's color flecks go "through-the-film"! Resists chipping, cracking and abrasion . . . defies alcohol, grease, and oil! So tough, it can be washed, scrubbed, even scoured with abrasive cleansers without surface damage!

PLEXTONE — DRAMATIC SALES APPEAL OF *MULTICOLOR!*

Color-flecked PLEXTONE offers endless new effects . . . from subtle tones-on-tone to brilliant spatter-dash . . . two, three or more colors sprayed from one gun at one time! New sales appeal for any and all products.

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A-4941

ALLIS-CHALMERS

How to detect and measure flange bending in gasketed joints

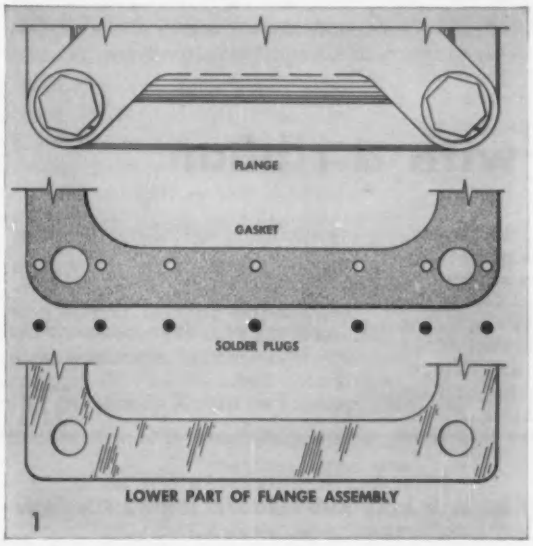
A surprisingly large percentage of gasket leaks is caused by almost undetectable bending or bowing that occurs between flange bolts, according to tests conducted at the Armstrong Research and Development Center.

Obviously, bending is most likely to be found where flanges are light, where bolts are widely spaced, or where bolting pressure is high. But it can also occur in heavy flanges, where bolts are not properly spaced.

Flange bending can cause leaks because it reduces the flange pressure on a gasket in the area midway between bolt holes and thus reduces gasket compression. Also, it may cause extrusion of the gasket near the bolts because of the concentrated pressure in these areas.

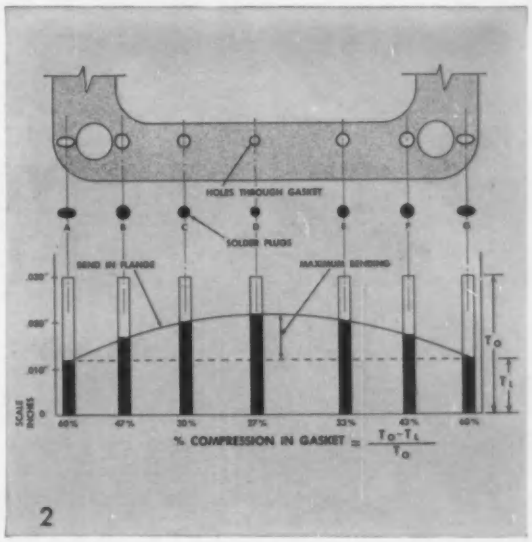
There are three qualitative ways and one quantitative way that an engineer can determine if flange bending is taking place.

1) *Pinpoint the leakage.* If leaks originate at center points between bolts, there's good reason to believe that flange bending is the source of trouble.
2) *Look for localized extrusion.* Extrusion near bolts—and not at midway points—indicates that flange bending is present.
3) *Check for varying gasket adhesion.* Flange pressure is one of the factors causing gasket adhesion. Consequently, where pressure is greatest, greatest adhesion should occur. If upon opening a leaky joint the gasket is found to be sticking more around bolts than at center, flange bending probably is occurring.



TO QUANTITATIVELY MEASURE FLANGE PRESSURE or gasket compression at any particular point, a simple yet accurate "solder plug" test devised by Armstrong research engineers can be used.

Drill several holes about 1/32 inch in diameter through thickness of gasket to be tested. Insert in these holes cylinders or plugs of soft solder. (Fig. 1) The plugs should be thick enough so that when the flanges compress the gasket, the plugs will also be compressed. Put gasket with solder plugs into flange and tighten bolts to desired torque.



Open the flange and measure thickness of solder plugs. Each plug obviously will measure exactly the same as the compressed thickness of the gasket at the point where it was located.

The extent of flange bending can be shown graphically by charting the solder plug thicknesses. (Fig. 2) If too much bending occurs, gasket will be overcompressed around bolts and undercompressed between bolts.

The percentage of compression can be easily calculated by using the formula in Figure 2. With this information, it is possible to determine whether the gasket material is within its recommended range at specific locations on the flange. The load-compression curves for the gasket material in question may be used to estimate unit loads. But these are relative unit loads and not absolute values. In addition, picking unit loads from load compression curves is applicable only to the compressible gasket materials such as cork composition.

SEND FOR 24-PAGE GASKET DESIGN MANUAL

You'll find other useful information on the design and use of gaskets in the new Armstrong Gasket Design Manual. Write for your copy of this manual to Armstrong Cork Company, Industrial Division, 7102 Irvin Street, Lancaster, Penna. For information on all Armstrong Gasket Materials, see Sweet's product design file.

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Workers easily roll this flexible, synthetic rubber ribbon along the edge of one aluminum sheet before screwing down the next. Fabric-reinforced EC-1202 is tough. It neither stretches, shrinks nor deteriorates, even during 140°F. paint drying. In fact, EC-1202 adheres so tightly it helps hold the metal together. The result—a uniform, economical, durable seal that shuts out water, dust and moisture for keeps.

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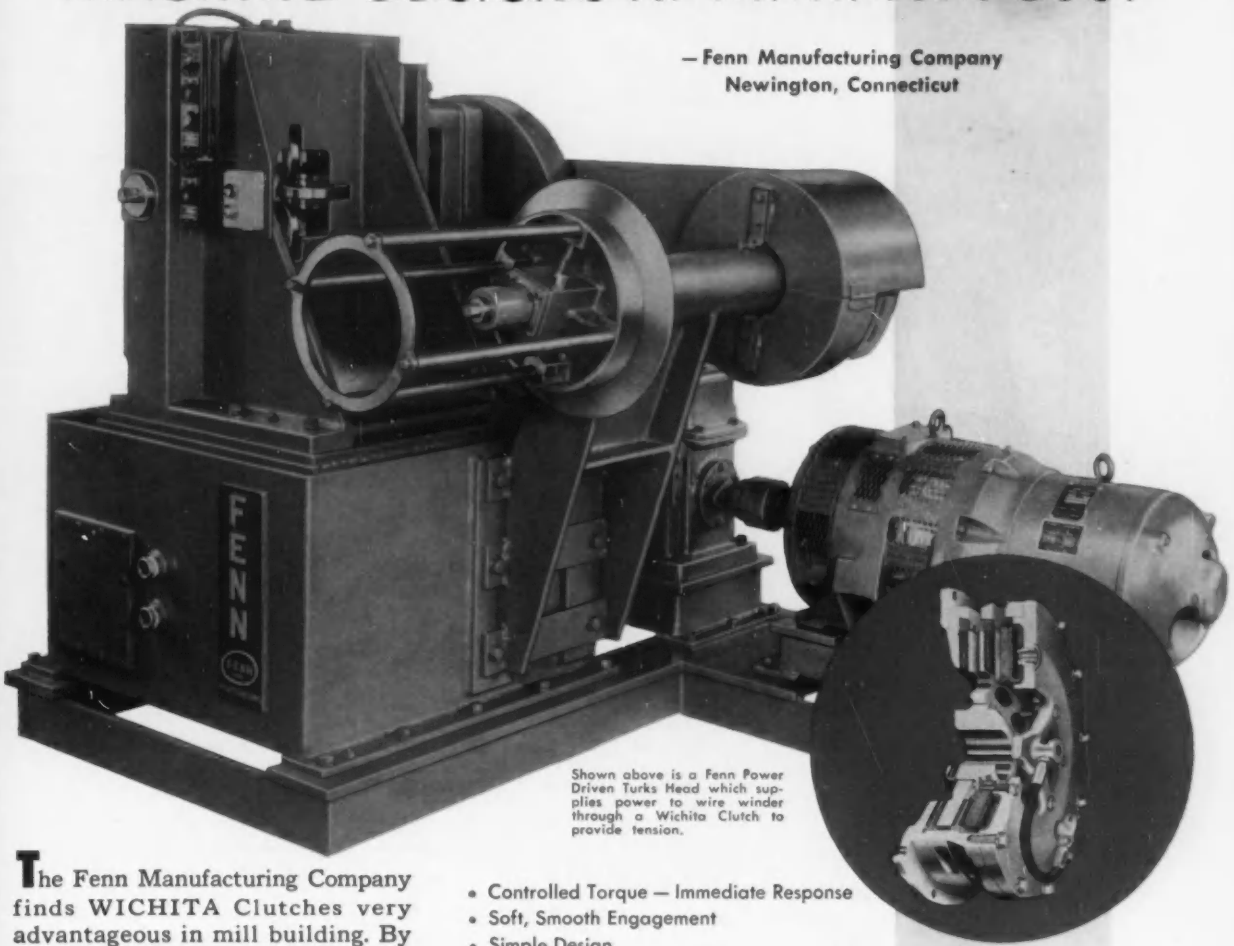

Shown above is a Fenn Power Driven Turks Head which supplies power to wire winder through a Wichita Clutch to provide tension.

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WICHITA Clutch COMPANY, INC.
WICHITA FALLS, TEXAS, U.S.A.

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It's a single piece of metal...

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ALUMINUM

Patents Applied for

Available in Copper, Brass, other Copper Alloys, and Aluminum

Here, for the first time, is a combination of tube and strip that is made from a single piece of metal! No joints! The product of intensive development by Revere's Research and Development Department, which sought and found a brand new way to give American industry tube plus strip that is more economical to buy, more economical to work, stronger and more efficient in performing 1,001 tasks.

Remember Revere Tube-In-Strip is solid, not two strips welded, brazed, or bonded together.

What does this mean to you? You buy strip, fabricate it as you wish, stamping, bending or forming it, and then as a final operation inflation expands the integral channels into tubes. Expanding in the open, the tubes are round; by expanding into dies, the tubes can be made rectangular, fluted, half-round, hexagonal, etc.

METALS: Copper, Brass, other Copper Alloys, Aluminum, many others.

ECONOMY: You save in first cost, and in fabrication. New and improved designs are made possible. The web between the tubes conducts heat faster. The vastly increased structural strength means you can use lighter gauges, saving in weight and in price.

The applications of this radically new, different and superior Revere Product are unlimited. We most proudly present Revere Tube-In-Strip to the designers and manufacturers of American Industry. The Revere Technical Advisory Service and the Research and Development Department will gladly collaborate with you in taking full advantage of this marvelous new material.

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- Transmission Oil Coolers

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Which one of these Genisco centrifuges meets your requirements for testing components under simulated operational G-loadings?

...as required by Mil 5272A, procedure II

Genisco G-Accelerators provide a quick, precise means of testing components in an acceleration environment similar to that encountered in actual operation.

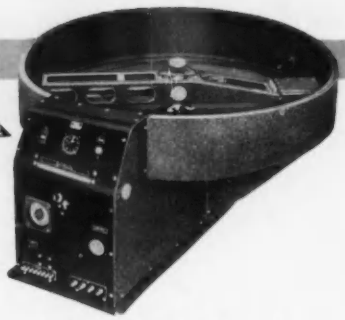
They are extremely accurate machines, easy to operate and built to withstand years of hard use.

These features particularly suit them for large volume testing programs, as well as for precise laboratory prototype development.

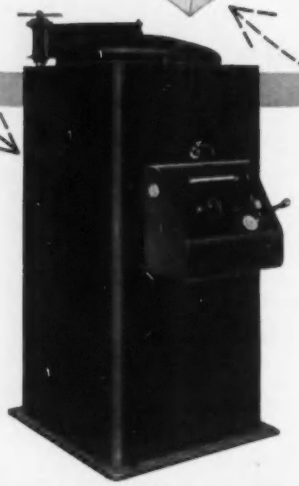
More than 100 Genisco G-Accelerators of various capacities are now in use throughout the world.

Complete technical information on all models and accessories is available. Please direct your inquiry to: Contracts Manager, Genisco, Inc., 2233 Federal Avenue, Los Angeles 64, California.

MODEL C159 The larger capacity of this machine permits whole system components and complete packages to be tested. Two objects, each weighing 100 pounds and 24" x 24" x 18" in size, can be accommodated simultaneously. G-range of the machine is 0.024 G to 75 G's. Maximum centrifugal capacity is 2000 G-pounds. Nominal radius of gyration 48".

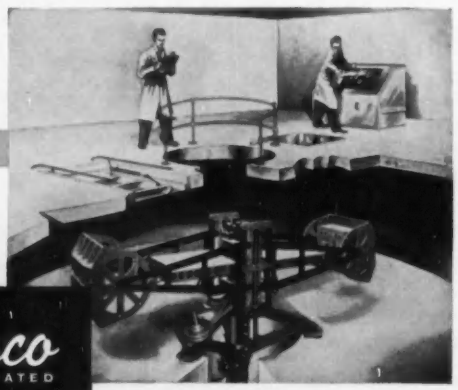


MODEL B78 Used primarily for testing relays, switches, tubes, motors, valves, and other small components, and to calibrate and evaluate accelerometers. Accommodates objects weighing up to 25 lbs.; has G-range of 0.017 G to 120 G's. Maximum centrifugal capacity is 1200 G-pounds. Nominal radius of gyration 24".



MODEL D184 A high-speed machine, designed to test accelerometers and other instruments under acceleration forces from 1 to 850 G's. Full centrifugal capacity is 1000 G-pounds. Nominal radius of gyration 12".

MODEL E185 This newest and largest Genisco centrifuge was recently built for the U.S. Air Force. Two mechanical or electronic packages, each weighing up to 300 pounds, can be subjected to an acceleration environment of up to 65 G's simultaneously. Nominal radius of gyration of the machine is six feet. An automatic dynamic balancing system automatically compensates for any excessive unbalance in the machine during test runs.



ACCESSORIES ADD TO OPERATING EASE A number of accessories including a strobe system, air system, optical system, tub cover, access doorway, and slip ring systems, designed to give greater operating convenience, are available for Genisco G-Accelerators, Models B78 and C159.

Modifications in any basic machine or accessories to meet your particular requirements will be carefully considered.

Genisco INCORPORATED

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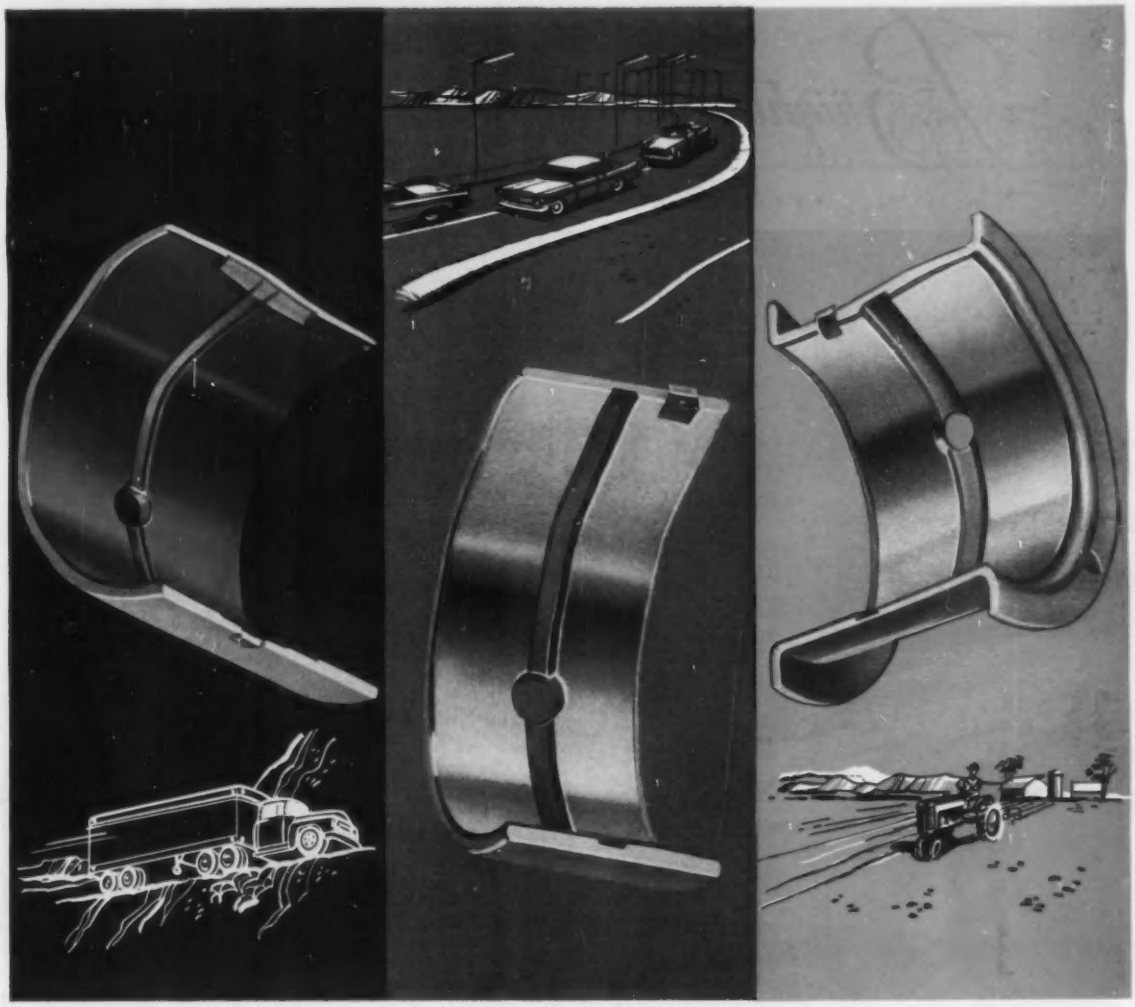

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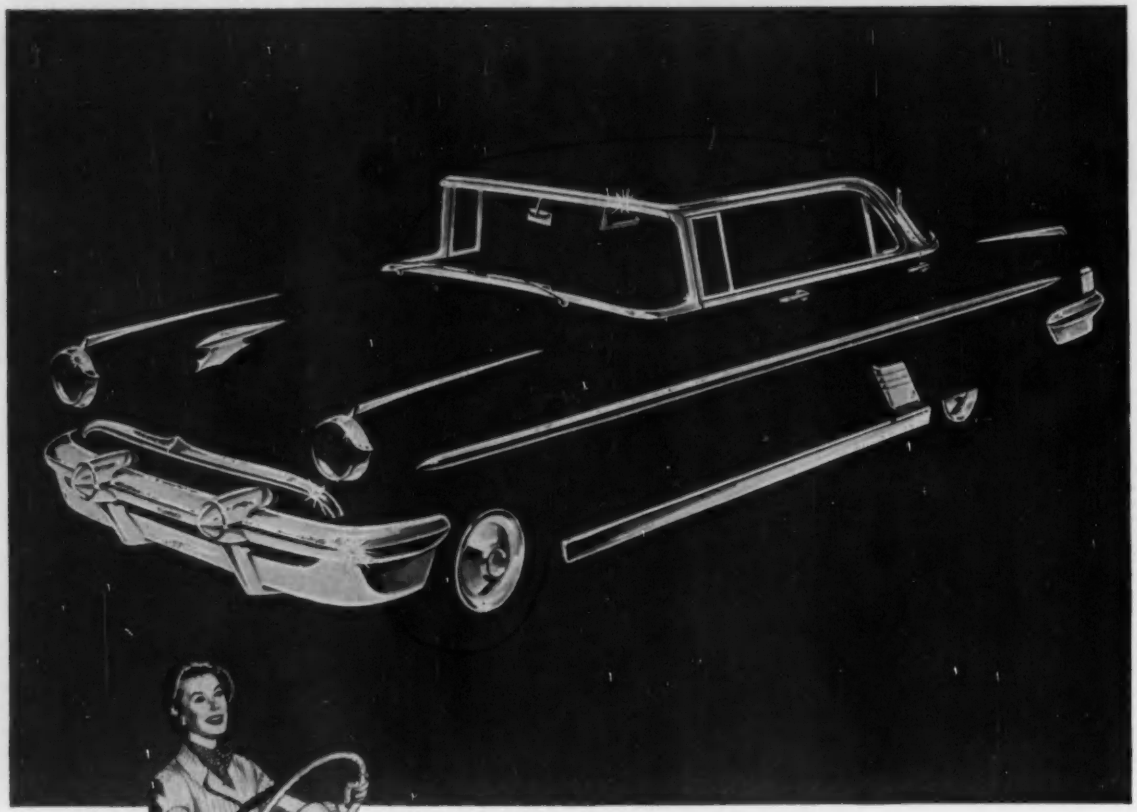

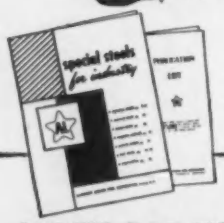

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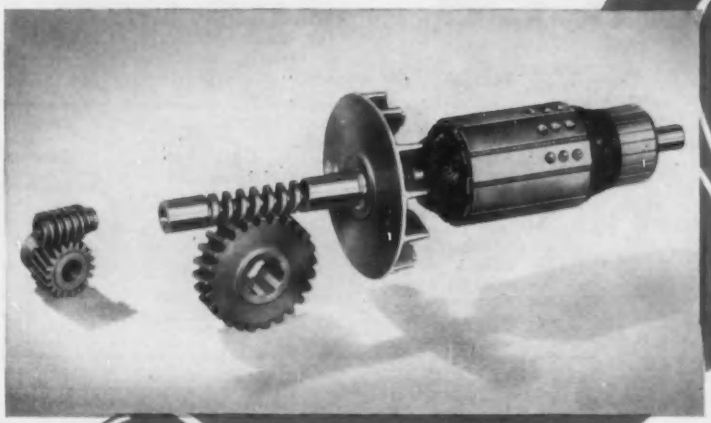

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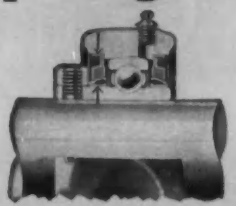

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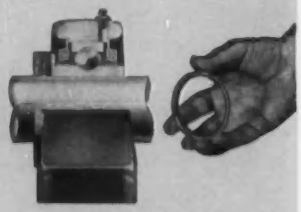

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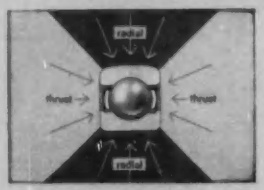

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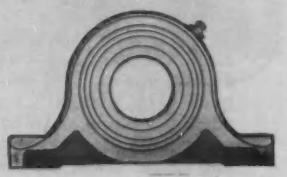

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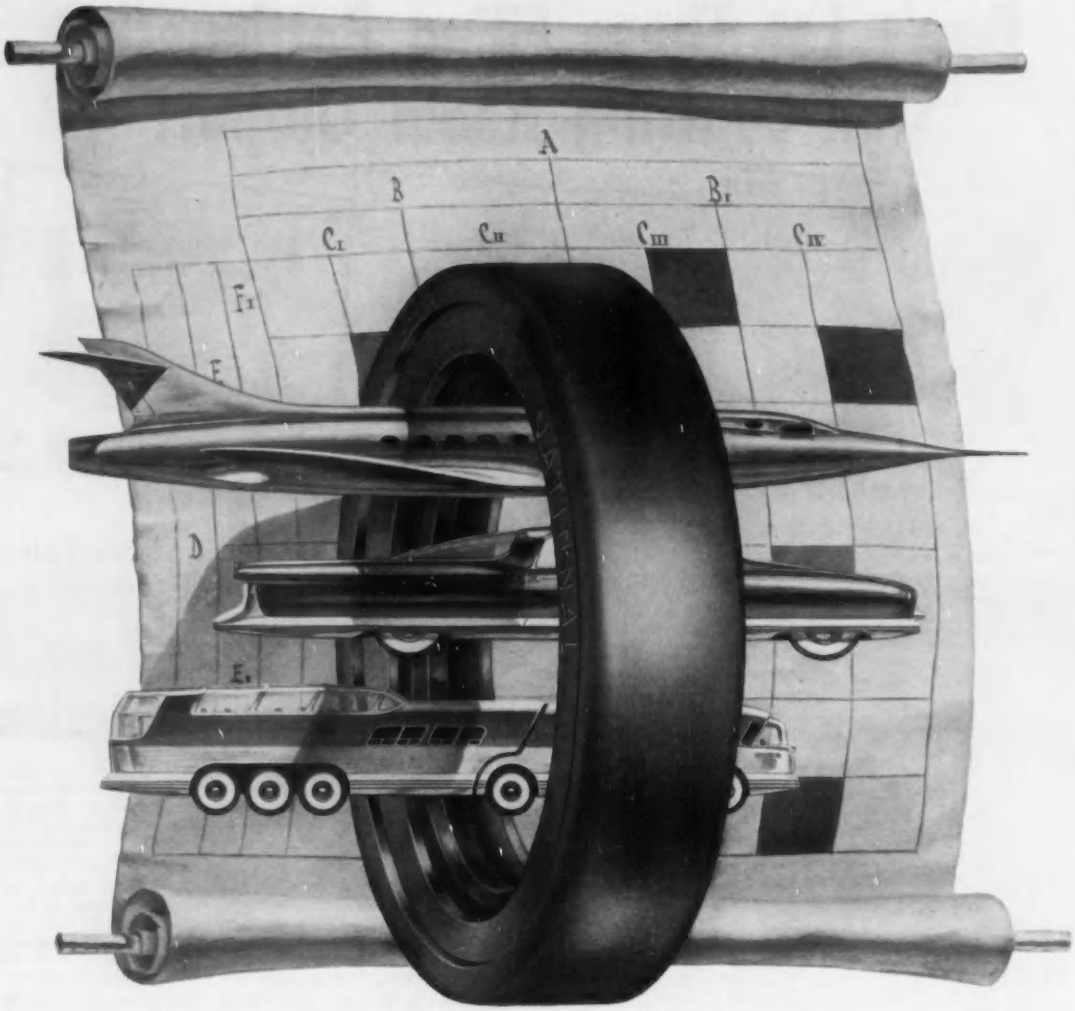

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C = Depends on conditions
X = Unsuitable

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	Asbestos			All Rubber					Misc.	
	Compressed sheet	Woven rubber	Woven neoprene	GR-S	Neoprene	Buna-N	Butyl	Natural	Plant-fiber sheet	Teflon
Acetic acid, crude	C	C	A	C	F	F	F	C	F	A
pure	C	C	A	C	F	F	F	C	F	A
vapors	C	C	A	C	F	F	F	C	F	A
150 p.s.i., 400 deg. F.	F	C	–	X	F	F	X	X	X	A
Acetic anhydride	–	C	A	–	C	–	–	–	–	A
Acetone	A	A	X	A	C	X	A	F	C	A
Acetylene	A	A	–	A	C	A	A	A	C	A
Air	A	A	A	A	A	A	A	A	A	A
Aluminum chloride	A	A	A	A	A	A	A	A	–	A
Aluminum fluoride	–	A	–	–	–	–	–	–	–	A
Aluminum sulphate	–	A	A	A	A	A	A	A	–	A
Alums	A	A	C	A	A	A	A	A	–	A
Ammonia gas, cold	A	A	A	A	A	A	A	A	A	A
hot	A	A	–	C	A	C	C	A	C	A
Ammonium chloride	A	C	A	–	A	–	C	A	X	A
Ammonium hydroxide	A	A	A	C	C	A	C	A	F	A
Ammonium nitrate	–	C	F	A	A	A	A	A	–	A
Ammonium phosphate, monobasic	–	C	A	A	A	A	A	A	–	A
dibasic	–	A	A	A	A	A	A	A	–	A
tribasic	–	A	A	A	A	A	A	A	–	A
Ammonium sulphate	A	A	A	A	A	A	A	F	F	A
Amyl acetate	A	A	C	X	X	X	–	F	C	A
Amyl alcohol	A	A	C	A	A	A	A	A	A	A
Aniline, aniline oil	A	A	–	X	F	X	A	X	–	A
Aniline dyes	A	A	–	F	F	F	A	F	–	A
Asphalt	F	A	–	X	F	F	X	X	F	A
Barium chloride	A	C	A	A	A	A	A	A	–	A
Barium hydroxide	A	A	A	A	A	A	A	A	F	A
Barium sulphide	–	A	–	A	A	A	A	A	–	A
Beer	A	A	X	A	A	A	A	A	A	A
Beet sugar liquors	A	A	X	A	A	A	A	A	A	A
Benzene, benzol	C	A	X	X	X	X	X	X	A	A
Benzine, petroleum ether, naphtha	C	A	X	X	A	X	X	X	A	A
Black sulphate liquor	A	A	–	A	A	A	A	A	X	A
Blast furnace gas	C	A	–	C	C	C	C	C	X	A
Borax	A	A	A	A	C	F	A	A	A	A
Boric acid	–	A	A	A	A	A	A	A	–	A
Bromine	X	X	X	X	X	X	X	X	X	A
Butane	A	A	–	X	F	C	–	X	X	A
Butyl acetate	A	A	X	X	X	X	F	C	X	A
Butyl alcohol, butanol	A	A	C	A	A	A	C	A	X	A
Calcium bisulphite	C	C	A	A	–	–	A	C	–	A
Calcium chloride	A	A	A	A	A	A	A	A	A	A
Calcium hydroxide	A	A	A	A	C	A	A	A	F	A
Calcium hypochlorite	A	C	A	C	C	A	A	C	F	A
Caliche liquors	–	C	–	–	A	A	A	A	–	A
Cane sugar liquors	A	A	A	A	A	A	A	A	F	A
Carbolic acid, phenol	–	A	C	X	C	X	X	X	–	A
Carbon dioxide, dry	A	A	–	A	A	A	A	A	X	A
wet	A	A	–	A	A	A	A	A	X	A
Carbon bisulphide	A	A	–	X	X	X	X	X	X	A
Carbon monoxide, hot	A	A	–	C	C	C	C	C	C	A
Carbon tetrachloride	F	A	X	X	X	X	X	X	C	A
Castor oil	A	A	X	A	A	A	A	X	C	A
China wood oil, tung oil	A	A	X	X	F	F	F	–	X	A
Chlorine, dry	F	A	X	F	F	F	F	F	X	A
wet	F	X	X	F	F	F	F	F	X	A
Chlorinated solvents, dry	C	A	X	X	X	C	X	X	X	A
wet	C	A	X	X	X	C	X	X	X	A
Chloroacetic acid	–	X	X	–	–	–	–	–	–	A
Chlorosulphonic acid	C	X	X	X	X	X	X	X	X	A
Chromic acid	C	X	X	X	X	X	C	X	C	A
Citric acid	C	C	A	F	A	F	C	A	F	A
Coke oven gas	A	C	–	C	A	C	C	C	X	A
Copper chloride	A	C	A	A	F	A	A	A	–	A
Copper sulphate	A	C	A	A	F	A	F	A	A	A
Corn oil	A	A	X	X	F	A	A	X	C	A
Cotton seed oil	A	A	X	X	F	A	A	X	X	A
Creosote, coal tar	A	A	–	X	F	A	X	X	X	A
wood	C	A	X	X	F	A	X	X	X	A
Cresols, cresylic acid	–	A	X	X	X	F	X	X	–	A
Dowtherm, A	C	A	X	X	X	X	X	X	X	A
E	C	A	X	X	X	X	X	X	X	A
Ethers	A	A	X	C	C	C	C	F	X	A
Ethyl acetate	A	A	X	C	X	X	F	F	A	A
Ethyl cellulose	F	A	–	F	F	F	F	F	X	A
Ethyl chloride	A	A	–	A	A	A	A	A	C	A
Ethylene glycol	A	A	C	A	A	A	A	A	A	A
Ferric chloride	–	C	C	A	C	A	A	A	–	A
Ferric sulphate	–	C	C	A	C	A	A	A	–	A
Formaldehyde	C	A	C	A	C	A	A	A	F	A
Formic acid	–	X	C	A	X	X	A	X	–	A
Freon	C	A	–	X	F	F	F	X	C	A
Fuel oil	A	A	–	X	F	A	X	X	X	A
Fuel oil, acid	–	A	–	–	–	–	–	–	–	A
Furfural	C	A	–	X	X	X	–	X	X	A
Gasolene, sour	–	A	–	X	A	A	X	X	–	A
refined	C	A	–	X	A	A	X	X	X	A
Gelatin	A	A	A	A	A	A	A	A	A	A
Glucose	A	A	A	A	A	A	A	A	A	A
Glue	A	A	A	F	A	A	F	A	C	A
Glycerin, glycerol	A	A	C	A	A	A	A	A	A	A
Green sulphate liquor	A	A	–	A	A	A	A	A	X	A
Hydrobromic acid	–	C	–	X	–	–	–	A	–	A
Hydrochloric acid, <150 deg. F.	F	C	A	F	F	A	A	A	–	A
>150 deg. F.	X	C	C	X	F	X	–	F	–	A
Hydrocyanic acid	–	A	–	–	–	–	–	–	–	A
Hydrofluoric acid, cold, <65%	X	X	–	F	A	–	F	F	X	A
>65%	X	X	–	X	X	X	C	X	X	A
hot, <65%	X	X	–	C	A	–	C	C	X	A
>65%	X	X	–	C	C	–	C	C	X	A
Hydrofluosilicic acid	A	X	–	A	F	A	A	A	X	A
Hydrogen gas, cold	A	A	–	F	A	A	A	F	C	A
hot	A	A	–	F	A	A	A	F	C	A
Hydrogen peroxide	–	A	X	F	A	–	F	F	–	A
Hydrogen sulphide, dry, cold	–	A	X	C	F	C	A	C	–	A
hot	–	A	X	C	F	C	A	C	–	A
wet, cold	–	A	X	C	F	C	A	C	–	A
hot	–	A	X	C	F	C	A	C	–	A
Kerosene	A	A	X	C	F	C	A	C	C	A
Lacquers	C	A	X	X	X	C	A	X	X	A
Lacquer solvents	C	A	X	X	X	C	A	X	X	A
Lactic acid, cold	A	A	X	C	C	C	A	C	C	A
hot	A	C	A	C	C	C	A	C	C	A
Linseed oil	A	A	C	C	F	A	A	C	C	A
Lubricating oils, sour	A	A	C	C	F	A	A	X	F	A
refined	A	A	C	F	F	A	A	X	F	A
Magnesium chloride	A	C	C	A	A	A	A	A	C	A
Magnesium hydroxide	A	A	C	C	A	A	A	A	C	A
Magnesium sulphate	–	C	C	A	A	A	A	A	–	A
Mercuric chloride	–	C	C	–	–	–	–	–	–	A
Mercury	–	C	A	–	–	–	–	–	–	A
Methyl alcohol, methanol	A	A	C	A	A	A	A	A	C	A
Methyl chloride	C	A	–	A	C	A	C	A	–	A
Milk	–	A	X	A	A	A	A	A	C	A
Mineral oils	A	A	X	C	F	A	A	X	C	A
Natural gas	A	A	–	F	A	A	A	A	–	A
Nickel chloride	–	C	A	A	A	A	A	A	–	A
Nickel sulphate	–	C	A	A	A	A	A	A	–	A
Nitric acid, crude	C	X	X	X	X	X	C	X	–	A
diluted	C	X	X	X	X	X	X	X	–	A
concentrated	X	X	X	X	X	C	X	X	–	A
Nitrobenzene	–	C	–	X	C	–	X	X	–	A
Oleic acid	A	A	–	F	A	A	–	F	–	A
Oleum spirits	–	X	X	–	–	–	–	–	–	A
Oxalic acid	A	X	A	F	–	–	–	F	C	A
Oxygen, cold	A	A	–	C	A	C	–	C	C	A
<500 deg. F.	C	A	–	C	A	C	–	C	X	A
500–1,000 deg. F.	–	A	–	–	A	–	–	X	–	A
>1,000 deg. F.	X	X	–	X	X	X	X	X	X	A
Ozone	–	–	–	–	–	–	–	–	–	–
Palmitic acid	A	A	–	F	A	A	F	F	C	A
Petroleum oils, crude, <500 deg. F.	A	A	X	C	A	A	X	C	X	A
>500 deg. F.	C	A	X	X	X	X	X	C	X	A
>1,000 deg. F.	X	X	X	X	X	X	X	C	X	A
Phosphoric acid, crude	A	X	C	C	C	C	C	C	–	A
pure, <45%	A	X	C	C	C	C	C	C	–	A
>45%, cold	A	X	C	C	C	C	C	C	–	A
hot	–	X	C	–	C	C	C	C	–	A
Picric acid, molten	–	A	C	–	C	A	A	C	C	A
water solution	A	X	C	A	A	A	A	A	A	A
Potassium chloride	–	A	A	A	A	A	A	A	–	A
Potassium cyanide	–	A	–	A	A	A	A	A	–	A
Potassium hydroxide	–	A	C	A	A	A	A	A	–	A
Potassium sulphate	–	A	A	A	A	A	A	A	–	A
Producer gas	A	A	–	–	–	–	–	–	–	A
Propane	A	A	–	–	F	A	–	–	–	A
Sewage	A	A	–	C	A	A	X	–	C	A
Soap solutions	A	A	–	C	F	A	–	C	C	A
Soda ash, sodium carbonate	A	A	A	A	A	A	A	A	A	A
Sodium bicarbonate, baking soda	A	A	A	A	A	A	A	A	A	A
Sodium bisulphate	A	C	A	A	A	A	A	A	A	A
Sodium chloride	A	A	A	A	A	A	A	A	A	A
Sodium cyanide	–	A	–	A	C	C	A	C	–	A
Sodium hydroxide	A	C	A	A	C	C	A	C	C	A
Sodium hypochlorite	A	C	A	A	C	C	A	C	C	A
Sodium metaphosphate	A	C	A	A	C	C	A	C	A	A
Sodium nitrate	C	C	A	A	C	C	A	C	–	A
Sodium perborate	C	A	–	A	C	C	A	C	–	A
Sodium peroxide	C	A	–	A	C	C	A	C	–	A
Sodium phosphate, monobasic	A	C	A	A	C	C	A	C	A	A
dibasic	A	A	A	A	C	C	A	C	A	A
tribasic	A	A	A	A	C	C	A	C	A	A
Sodium silicate	A	A	A	A	A	A	A	A	–	A
Sodium sulphate	A	A	A	A	A	A	A	A	–	A
Sodium sulphide	A	A	–	A	A	A	A	A	–	A
Sodium thiosulphate, "hypo"	A	A	A	A	–	A	A	A	A	A
Soybean oil	A	A	–	C	A	A	A	C	A	A
Stannic chloride	A	X	A	A	A	A	F	A	C	A
Steam, <500 deg. F.	A	A	–	A	X	X	–	C	X	A
500–1,000 deg. F.	C	A	–	X	X	X	–	X	X	A
>1,000 deg. F.	X	C	–	X	C	X	–	X	X	A
Stearic acid	A	A	X	X	A	A	C	X	C	A
Sulphur	A	A	–	F	X	A	F	C	C	A
Sulphur chloride	C	X	–	A	A	F	X	X	X	A
Sulphur dioxide, dry	A	A	–	C	C	C	C	A	–	A
Sulphur trioxide, dry	–	A	–	C	C	C	C	A	–	A
Sulphuric acid, <10%, cold	A	F	A	A	A	A	A	A	–	A
hot	A	F	X	A	A	A	A	A	–	A
10-75%, cold	F	X	X	C	C	C	A	C	–	A
hot	F	X	X	C	C	C	A	C	–	A
75-95%, cold	C	X	X	C	X	C	A	C	X	A
hot	C	X	X	C	X	X	A	C	X	A
fuming	X	X	X	X	X	X	C	X	–	A
Sulphurous acid	A	X	A	A	C	C	C	A	–	A
Tannic acid	–	A	A	–	C	C	C	C	X	A
Tar	A	A	–	C	C	C	X	C	X	A
Tartaric acid	–	A	A	C	C	C	C	A	X	A
Toluene	A	A	X	X	F	C	A	X	X	A
Trichloroethylene	C	A	X	X	C	A	X	C	X	A
Turpentine	A	A	X	C	C	A	X	C	X	A
Vinegar	A	A	A	A	C	C	A	A	C	A
Water, acid mine, cont'g oxidizing salts or no oxidizing salts	A	A	A	A	C	C	A	A	C	A
Water, fresh (tap, b'l'r f'd, etc.)	A	A	A	A	C	A	A	A	A	A
distilled, lab. grade	A	A	X	A	C	A	A	A	A	A
return condensate	A	A	C	A	C	A	A	A	A	A
Water, seawater	A	A	C	A	X	A	A	A	A	A
Whiskey and wines	A	A	X	A	C	A	A	A	A	A
Zinc chloride	C	X	A	C	A	C	A	A	A	A
Zinc sulphate	A	X	A	A	A	A	A	A	A	A

Chemical Resistance of Gasket Materials

This chart enables you to select accurately the right "U.S." Gasket for corrosion service

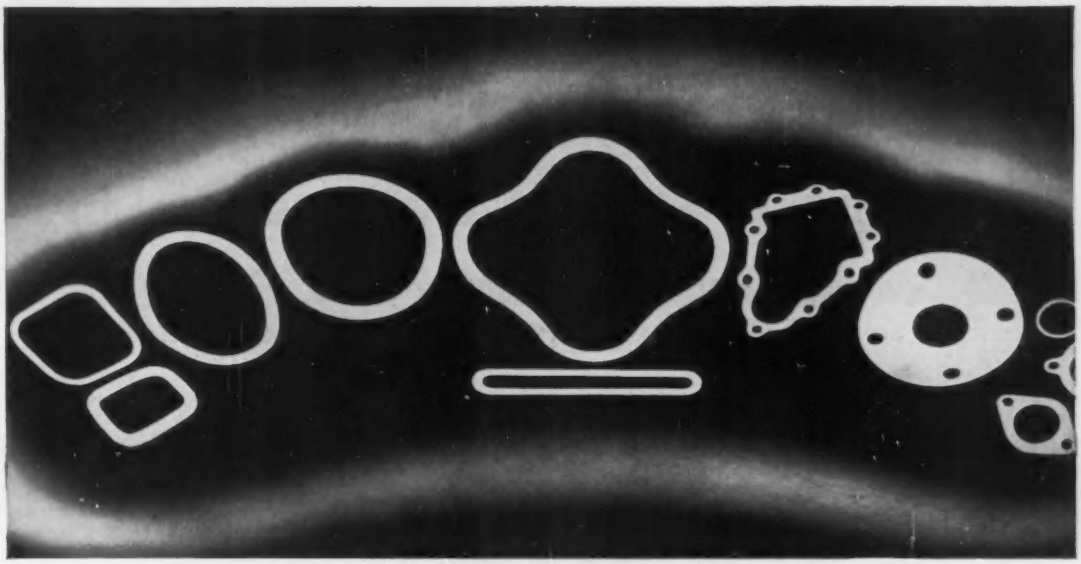
SEND FOR YOUR FREE REPRINT

The chart will be useful in indicating the degree of safety with which the various materials may be used in the service shown.

Those materials known to be suitably resistant have been rated as "A." Those whose resistance is only fair, but not so low as to be dangerous, have been given an "F" rating. An "X" denotes that the material is totally unsuitable. The "C" rating means that the use of this material is dependent upon specific service conditions and should not be selected unless carefully investigated. The blank spaces for the most part represent absence of data.

The generally accepted temperature limit for a good grade compressed asbestos sheet, also called asbestos composition sheet, is 750 deg. F. However, some grades are successfully used at considerably higher temperatures. This type of sheet is used for smooth flanges. For rough flanges, gaskets cut from woven asbestos-metallic sheet or gaskets formed by folding asbestos-metallic cloth are preferred. The latter material is preferable for flanges when bolt pressures are necessarily limited due to the type of flange material.

The all-rubber materials are recommended for temperatures up to 300° F. Higher temperatures are sometimes used but with a lesser degree of safety. Pressures are determined by the type of flange surface.



Examples of U. S. Rainbow Gaskets, Style No. 4009

Outstanding members of the "U. S." line of gaskets. Recommended for packing flanges or other parallel surfaces against hot or cold water, air, saturated steam pressures up to 150 pounds, and all hydraulic conditions.

These gaskets are cut from U. S. Rainbow® Sheet Packing, Style No. 9. They have all the resiliency, pliability and adaptability of the famous Rainbow original Red Sheet Packing. Furnished in any shape, size or thickness.

U. S. Packings and Gaskets are obtainable through any of our 27 District Sales Offices or selected "U. S." distributors, or write to us at Rockefeller Center, New York 20, N. Y.

Mechanical Goods Division

United States Rubber

Lifting capacity of this Austin-Western crane was increased 350% with Cone-Drive gearing. The boom lifting mechanism is driven by a 6" center distance 50:1 Cone-Drive gearset powered by hydraulic motor. A similar 5" center distance 40:1 Cone-Drive unit swings the crane.

Engineers give crane tremendous "lift"

New material selected for component helps increase boom capacity 350%

THE INCREASED LIFTING POWER given to this crane emphasizes the intimate interdependence of design and materials. A compact boom mechanism was essential. A mechanism small in size, but decidedly stronger than any former type.

Study ruled out the usual gearing. And usual metals lacked enough stamina for heavier shocks, brutal stresses, jerks, twists and overloads. So the answer?

Here, agreed the designers, was a job made to order for Cone-Drive gearsets. Because the compact Cone-Drive provides ample strength. It mates a nickel alloy steel worm with gearing of chill-cast nickel alloyed bronze.

Added to bronze, nickel imparts extra life and strength, raises elastic properties, and increases shock resistance as much as 25 to 50 per cent.

Likewise, nickel contributes much to the worm. Cone-Drive worms are medium-carbon nickel-chromium-molybdenum steel, heat treated to a minimum hardness of 32 Rockwell C and 140,000 psi tensile strength.

The nickel content in this steel helps make possible a surface that resists wear and spalling . . . and a core with the toughness to withstand severe overloads.

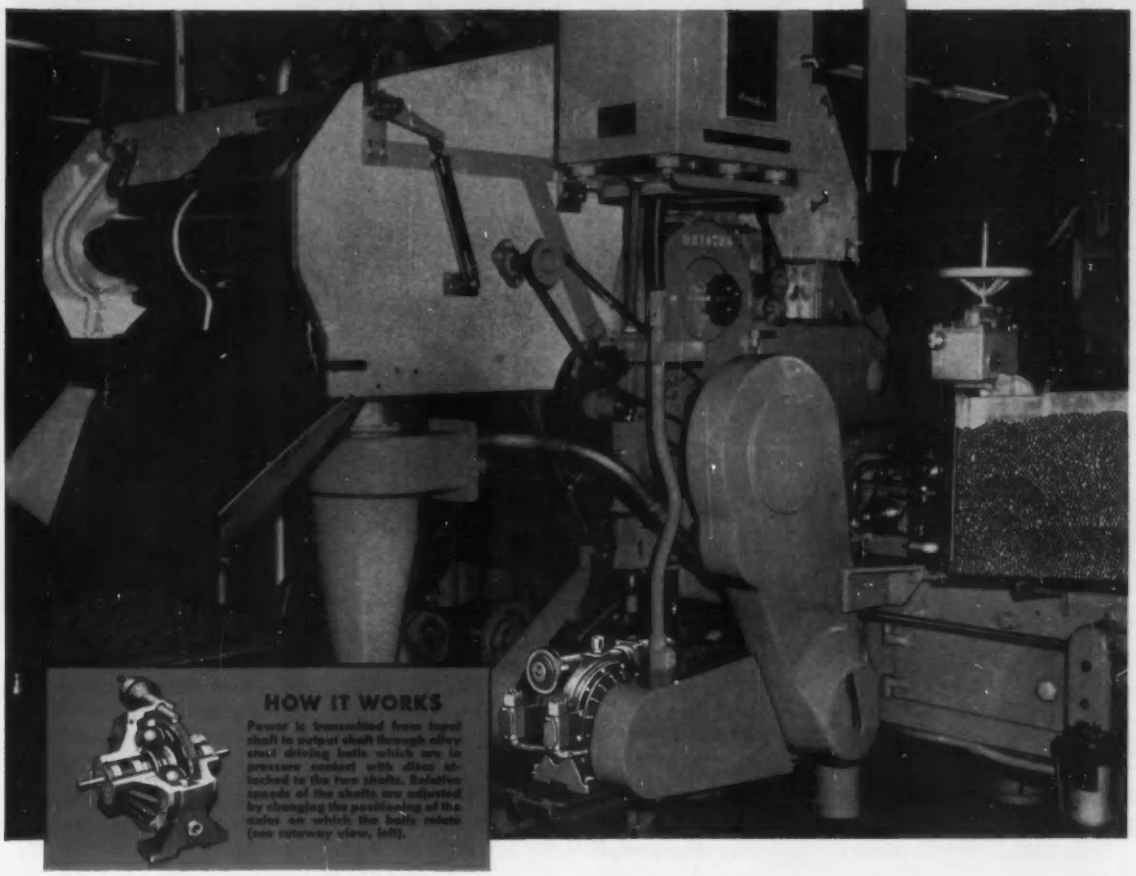
In many a metal, you can improve specific properties by use of nickel alone or in combination with other alloy elements. When you have a metal problem, whatever the difficulty, send us details. We'll be glad to give you suggestions based on our wide experience in this field.

INCO TRADE MARK

THE INTERNATIONAL NICKEL COMPANY, INC. 67 Wall Street New York 5, N.Y.

AccuRay electronic brain gets muscle power from Cleveland Speed Variator

The electronic control mechanism of this cigarette machine, known as the AccuRay cigarette gage controller, built by Industrial Nucleonics Corp., Columbus, Ohio, employs Cleveland Speed Variator size 4K4, driven at 1200 rpm input.



HOW IT WORKS

Power is transmitted from input shaft to output shaft through alloy steel driving balls which are in pressure contact with discs attached to the two shafts. Relative speeds of the shafts are adjusted by changing the positioning of the axles on which the balls rotate (see cutaway view, left).

NATIONALLY famous for checking and controlling the making of Chesterfield cigarettes, AccuRay depends on a Cleveland Speed Variator for the delicate job of adjusting the tobacco feed rate in response to impulses from the gaging mechanism.

Being infinitely variable, the Cleveland Speed Variator gives stepless speeds over a full 9:1 range — from ⅓ to 3 times input speed. Output speed on this application is adjusted automatically by a regulating motor mounted on the Variator — but could be regulated manually or by remote controls of other types.

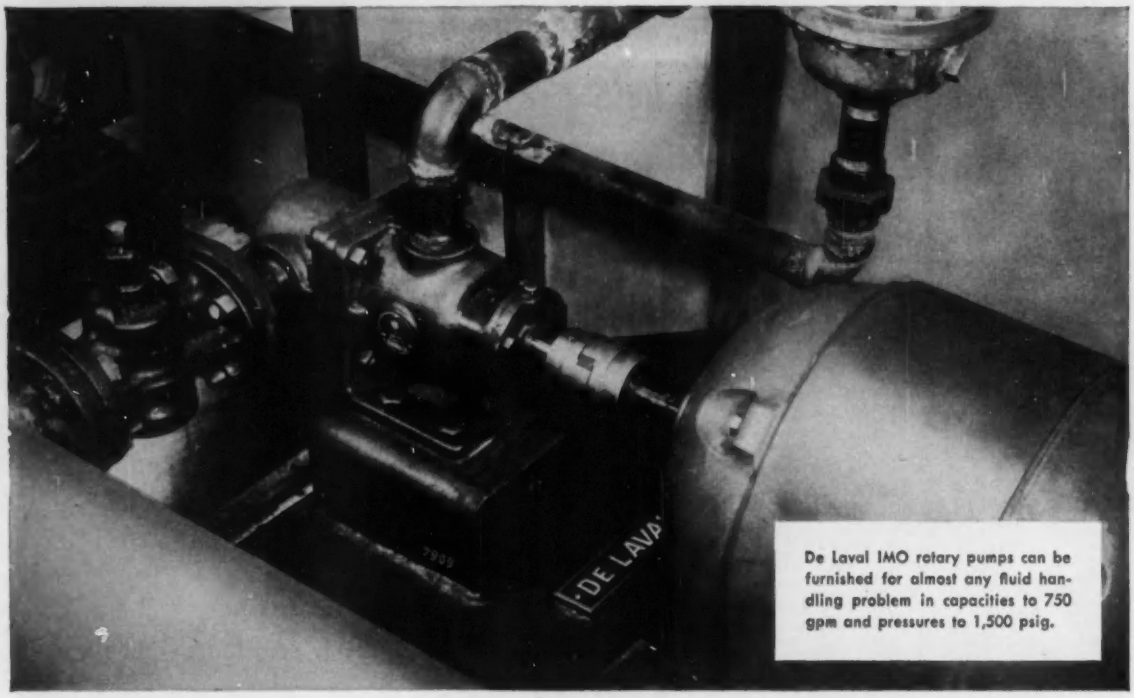
Available in eighteen standard types and sizes, the Cleveland Speed Variator offers these major advantages: 1. An extremely compact unit with input and output shafts in line and rotating in the same direction; 2. Almost any input speed up to 1800 rpm can be used — either clockwise or counterclockwise rotation; 3. Rated for constant horsepower output over a 9:1 range, or for constant output torque with a 6:1 range; 4. Infinitely variable over the entire speed range; 5. Rapid response to speed change, precise adjustment, and accurate maintenance of speed settings; 6. Long life and minimum maintenance due to absence of belts or complicated linkages; 7. Ample bearing support for overhung pulleys on either input or output shafts.

Write for Bulletin K-200 for detailed description with photographs, sectional drawings, rating tables and specifications.

THE CLEVELAND WORM AND GEAR COMPANY

Speed Variator Division, 3279 East 80th Street, Cleveland 4, Ohio

Sales Representatives in all major industrial markets • In Canada—Peacock Brothers Limited



De Laval IMO rotary pumps can be furnished for almost any fluid handling problem in capacities to 750 gpm and pressures to 1,500 psig.

What to Look for in a Rotary Screw Type Pump

By W. J. MONGON, *Assistant Chief Engineer*
De Laval Steam Turbine Company

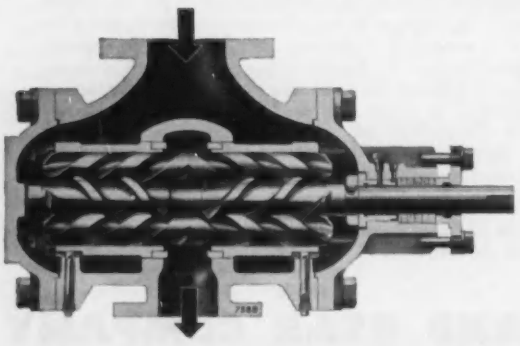
A sound knowledge of design, and how it affects performance, is the best insurance a buyer can have that he will get the pump he needs. This brief analysis of the IMO, a rotary three-screw pump manufactured by the De Laval Steam Turbine Company, will give you some of the necessary facts.

What qualities should you look for in a rotary type pump? It must, of course, meet specified capacities and pressures. But, it must also be efficient, operate quietly, stay on the job.

The axial flow of a screw type pump, and the resulting low inlet losses for any given pump speed, are important benefits that should be considered in making pump selections. The absence of timing gears and other mechanical features of construction also enable the De Laval IMO pump to operate at direct-connected motor and turbine speeds . . . to handle viscous liquids and high suction lifts.

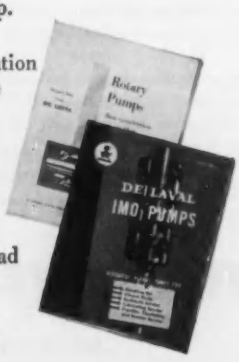
One of the most important features of the IMO pump is the hydraulic turning of the idler or sealing rotors. The central or power rotor is the pumping element; the liquid pumped turns the sealing rotors.

A screw type pump is well suited for applications where pulsation-free flow is desirable. The axial flow of the liquid without trapping and the unique thread form which keeps closures fluid-tight contribute to quiet operation of the IMO pump.



De Laval IMO Series A322A, a positive displacement, rotary screw type pump, can handle capacities to 750 gpm and pressures to 150 psig.

Catalog LS gives useful application and specification data on the IMO pump. An article titled, *Rotary Pumps, Basic Considerations in Their Application*, contains a description of rotary pumps in general. For these publications, write on your company letterhead to De Laval Steam Turbine Company, 801 Nottingham Way, Trenton 2, New Jersey. DL-301



Anaconda Wire now available in New Pay-off Container

BUCKLES AND BUCKLE PARTS made by West Haven Buckle Co., West Haven, Conn., using Anaconda 70-30 yellow brass wire. Finished buckles, later nickel plated, are of highest quality, noncorroding, for use in surgical bandages, trusses, corsets and other surgical appliances.

Shutdowns to change coils in wire forming machines cut 90% at West Haven Buckle Company

The West Haven Buckle Company of West Haven, Conn., used to be limited to relatively light coils of brass wire because of the slide feed necessary for free pay-off into its wire forming machines. Machines could operate less than an hour before shutdown to feed in another coil.

When they started using Anaconda Wire packaged in the *new pay-off barrel*, which provides free pay-off, the runs were increased 10 times. The big coils of brass wire—400 to 500 pounds—made possible continuous runs of from 8 to 9 hours. This cut the time lost in changing coils 90 per cent. It eliminated the labor of shifting and lifting heavy coils—as the wire is fed directly from the barrel.

An easy way to increase production, cut costs: Big coils of Anaconda Wire in the *new pay-off barrel* give you these advantages:

1. Reduced down-time to change coils can mean production increases up to 25 per cent. Free pay-off feature may enable you to increase machine speed for still greater production.
2. Operators are freed for other duties during the longer continuous runs.
3. Easier handling, better inventory control. Barrels are clearly marked for quick identification—are easily handled by standard hand trucks—utilize storage space efficiently—can be stacked. Losses are minimized because coils stay clean indefinitely—there is no danger of coils becoming tangled or mixed.

No extra charge for Anaconda Wire in the new pay-off container. Call your American Brass Company representative today or write: The American Brass Company, Waterbury 20, Conn.

5685

THE NEW CONTAINER which provides Anaconda Wire in 400 to 500 pound coils, ready for free pay-off into pin machines and other automatic forming machinery. Anaconda wire in all alloys is available packaged this way for long, continuous runs—in all gages up to .090", in tempers at least one number hard.

ANACONDA®

COPPER AND COPPER ALLOY WIRE

EXON: each resin engineered for a specific problem

EXON solution resins

varying in properties to suit specific needs

Your needs are the blueprints of Firestone engineers. There are several distinctly different Exon solution resins to solve industry's varied problems regarding application, purpose, performance conditions and surfaces. The significance is this: if you require a solution resin specifically engineered to fit your particular set of problems, you're likely to find it in the growing line of Firestone Exon resins. For example:

Firestone

EXON 450 Good solubility, film tensile strength and durability allow formulations to be based on this one resin alone. Coatings can be spray-applied, and strip off cleanly and easily.

EXON 461 Fluorinated, non-flammable, thermoplastic. Soluble in aromatic, ketone and ester type solvents. Films adhere to porous substrates, show excellent heat and light stability, exceptionally low vapor transmission, good resistance to inorganic chemicals including concentrated acids and alkalies.

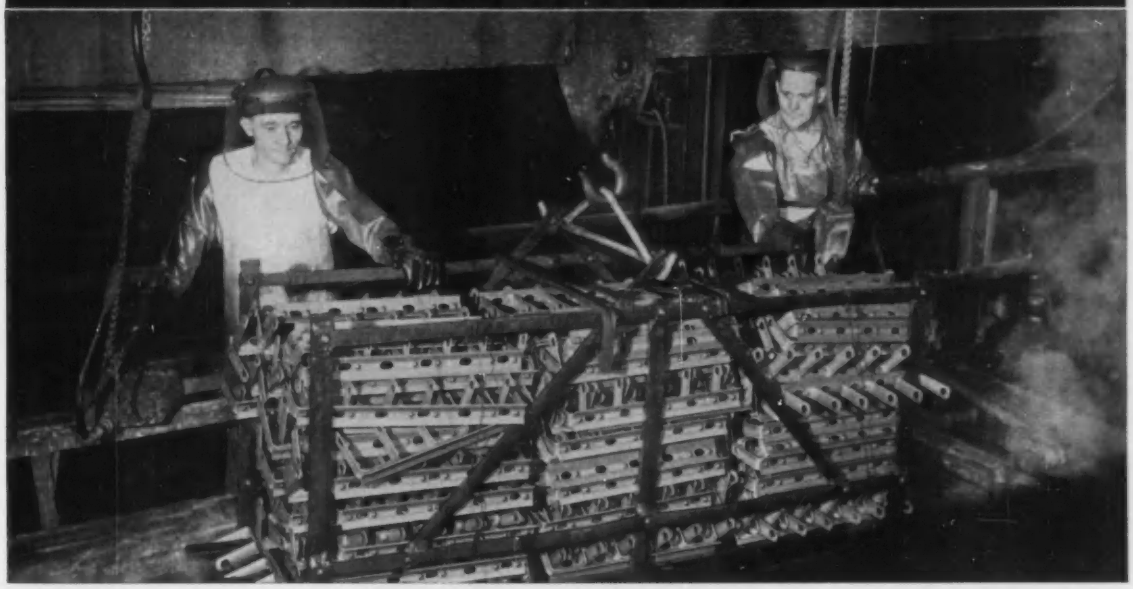
EXON 470 Excellent adhesion to metals, alkyd and vinyl surfaces. Compatible with various drying oils, alkyds, phenolics and melamines. Highly soluble in ketone solvents. Good aromatic tolerance.

EXON 471 has excellent solubility. Unmatched as a protective coating. Corrosion resistant, adheres to vinyl, paper and cloth. Will adhere to wash primer. Common lacquer techniques can be used in application of coatings. Numerous solvent systems are possible, permitting use in a wide variety of applications.

For complete details on these and all other Firestone Exon resins, write:

CHEMICAL SALES DIVISION
FIRESTONE PLASTICS COMPANY, POTTSTOWN, PA., DEPT. 66D
DIVISION OF THE FIRESTONE TIRE & RUBBER CO.

How's this for corrosion control?



Carpenter Stainless No. 20 pickling rack still in H_2SO_4 service after 5½ years!

Steady exposure to 5-15% sulphuric acid at temperatures up to 200°F for over 5½ years is the service record of this pickling rack made from Carpenter Stainless No. 20. It supports heavy loads of pole line hardware during pickling. Dependable corrosion resistance in the steel is invaluable.

Ordinary steels lasted but a short time on this application. Then, Carpenter Stainless No. 20 was put to work. The result is added safety for the workers, substantial savings in replacements, and uninterrupted production.

Today industry is finding a host of uses for this super corrosion-resisting steel. A wide variety of products of No. 20 can be purchased already fabricated . . . or you can build your own. In addition to hot sulphuric acid, this unique steel resists attack by a long list of other corrosives.

Whatever your corrosive application, talk to Carpenter first about the cost-saving advantages of No. 20. Over 70 years' experience in the development and manufacture of specialty steels are at your service when you contact your nearest Carpenter Mill-Branch Warehouse, Office or Distributor. *The Carpenter Steel Co., 117 W. Bern St., Reading, Pa.*

Partial list of Stainless No. 20 products now being fabricated:

- Agitating equipment
- Baskets
- Centrifugal pumps and parts
- Coils
  - Heating and cooling
- Dehydrators
- Exchangers, Heat
- Fans
- Fastenings (all types of standard and special design)
- Fittings
- Grommets
- Hangers
- Instruments
  - Heat and temperature
  - Industrial liquid level
- Mixers
- Nozzles
- Pails for sulphuric acid
- Pipe
- Processing equipment (food and chemical industry)
- Pump parts
- Screws
- Tanks, welded
- Thermocouple wells
- Tube
- Valve parts
- Valves
- Vessels, welded
- Weld rods
- Wire
  - Baskets
  - Cloth
  - Stranded
- And others

Carpenter Stainless No. 20-Cb is available from The Carpenter Steel Company, Alloy Tube Division, Union, New Jersey, in the forms of tubing, sheet, strip, pipe and plate; and Stainless No. 20 in the forms of bars, billets and wire.

Our new leaflet "*Positive Protection*" has a more complete list of available products made from No. 20. If you haven't a copy, please drop us a line.

Visit Our Booth
INDUSTRIAL EXPOSITION
INTERNATIONAL AMPHITHEATRE
CHICAGO . . . . . MARCH 19-23, 1956

Carpenter STEEL

Super Corrosion-Resistant Stainless

Pioneering in Improved Tool, Alloy and Stainless Steels Through Continuing Research
Export Department: The Carpenter Steel Co., Port Washington, N. Y.—"CARSTEELCO"

P-K® ASSEMBLY ENGINEERS ARE TRAINED TO HELP YOU DESIGN BETTER PRODUCT FASTENINGS AT LOWER COST

There's a Parker-Kalon Assembly Engineer nearby—ready to work for you. He's a fastener specialist with the experience and skill to help with your particular problem. Perhaps, he can show you how to eliminate some fasteners from your design—or suggest the use of less expensive types of fasteners. That's part of his job. Take advantage of this unique service while your product is still in the design stage. Call your local Parker-Kalon distributor and have him send a P-K assembly engineer to your office. This service is another reason why industry finds... if it's P-K, it's O.K.!

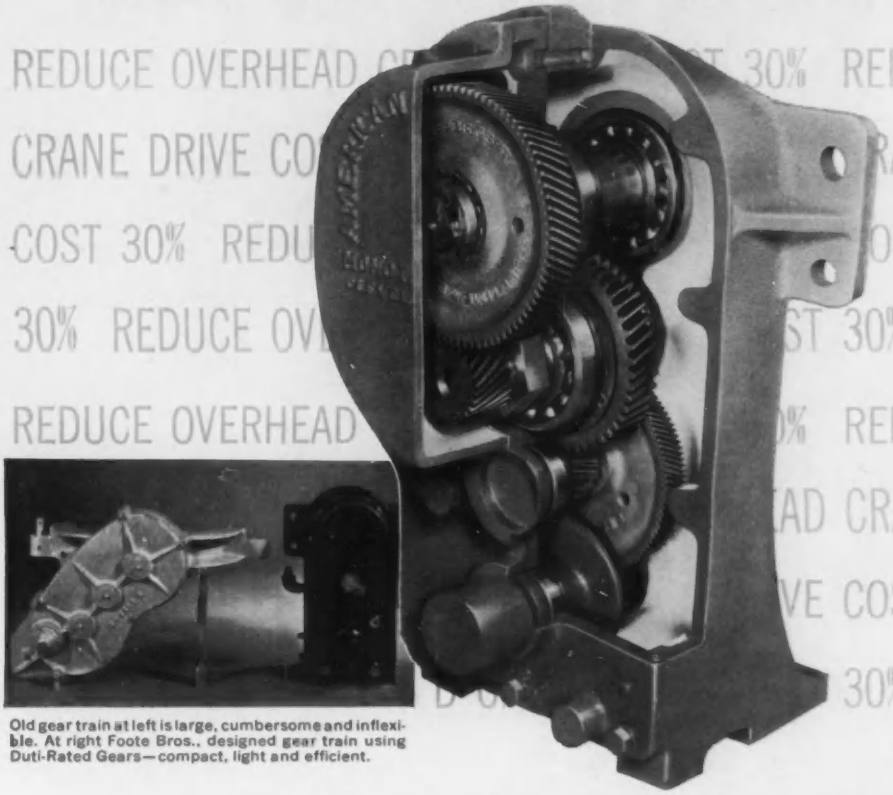
Sold Everywhere Through Leading Industrial Distributors. Warehouses in Chicago, Illinois, Los Angeles, California

PARKER-KALON® *fasteners*

PARKER-KALON DIVISION • GENERAL AMERICAN TRANSPORTATION CORPORATION • CLIFTON, NEW JERSEY

Dutt-Rated Lifetime Gears

REDUCE OVERHEAD CRANE DRIVE COST 30%



Old gear train at left is large, cumbersome and inflexible. At right Foote Bros., designed gear train using Duti-Rated Gears—compact, light and efficient.

100% more capacity - 25% less weight - 28% less size

Ordinary commercial gearing in the traversing drive for an overhead, traveling crane system was bulky and had to be set at a space wasting 45° angle to save head room. Foote Bros. designed a special transmission system using Lifetime Duti-Rated Gears, permitting the application of smaller gears for the same capacity, allowing shorter center distances and a much more compactly designed drive.

The savings in space not only improved the design and performance of the overhead crane but also life expectancy. Maintenance requirements were greatly reduced. An outstanding feature of the new drive was that the Duti-Rated Gears could be interchanged on the same centers to change the ratios . . . allowing various speeds, fast and slow, for traversing.

This is only one example of what Duti-Rated Gears are doing in industry today. Extra gear capacity in less space . . . with longer life and lower costs . . . could be important to you, too. Call Foote Bros. today and learn all the advantages of Duti-Rated Lifetime Gearing . . . pre-engineered as standard or designed for your application. *FREE! Foote Bros. Engineering Manual "Duti-Rated Lifetime Gearing". Write for your copy today!*

This trademark stands for the finest industrial gearing made!

FOOTE BROS. Duti-Rated® LIFETIME GEARING

T.M. Reg. U.S. Pat. Off.

FOOTE BROS.

Better Power Transmission Through Better Gears

Foote Bros. Gear and Machine Corporation
4545 South Western Boulevard, Chicago 9, Illinois

satisfied customers have readymade audiences!

GM GENERAL MOTORS

Packard

REG. U.S. PAT. OFF. TRADE MARK

Packard Electric Division
General Motors, Warren, Ohio

Here's a man who is really happy about his new oil furnace . . . an enthusiastic booster who can hardly wait to tell about it. Chances are that a Packard Electric motor has a lot to do with his satisfaction . . . for Packard motors deliver quiet, dependable, long-lasting performance that's bound to please.

For more than 39 years, Packard Electric craftsmen have been building fractional horsepower motors that lead to one customer telling another. Packard builds a lot of satisfaction into every motor . . . and there's nothing better than a satisfied customer to boost both reputation and sales.

New Du Pont MYLAR
REG. U. S. PAT. OFF.
adds improved qualities to pressure-sensitive tape
Pressure-sensitive tapes made with new Du Pont "Mylar"* polyester film are giving superior performance in a wide variety of diversified industrial uses. That's because tapes made with "Mylar" offer long-lasting strength in conjunction with chemical resistance, dielectric strength, and thermal stability.
Whether it's masking for electroplating or harness-wrapping coils, pressure-sensitive tapes made with new Du Pont "Mylar" increase efficiency, improve performance and, in the case of electrical applications, help decrease weight and size of the finished product.
Du Pont manufactures only the base material, "Mylar." The various firms that make pressure-sensitive tapes using "Mylar" offer a variety of gauges, widths, and types of adhesives. Send in coupon below for names of manufacturers and the new booklet listing properties and applications of pressure-sensitive tapes made with "Mylar."
Thin, yet strong . . . gives a snug wrap over irregular, bulky surfaces.
Amazing dielectric strength, thermal stability, for countless electric uses.
Dimensionally stable, can be used over a wide range of temperatures.
Can be metalized, printed, used for coding pipes and wires . . . decorative effects.
Resists edge fraying, has great tear strength... is ideal for tough jobs.
Resists effects of corrosion and moisture over wide range of temperature and humidity.

*Registered Du Pont trademark for its brand of polyester film

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. . . THROUGH CHEMISTRY

DU PONT MYLAR® POLYESTER FILM

☐ Please send me further information on the basic properties of "Mylar."

☐ Please send me your new booklet on pressure-sensitive tapes made with "Mylar" and names of manufacturers.

E. I. du Pont de Nemours & Co. (Inc.)
Film Dept., Room P-1, Nemours Bldg., Wilmington 98, Del.

Name _____

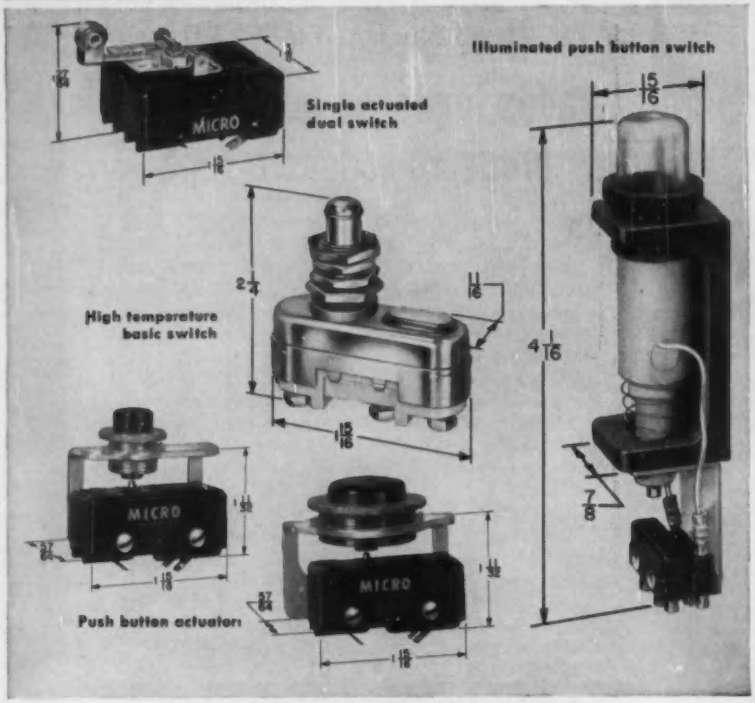
Firm _____

Street Address _____

City _____ *State* _____

MICRO precision switches

...THEIR USE IS A PRINCIPLE OF GOOD DESIGN



A continuous flow of Precision Switch developments anticipates designers' needs

Function of MICRO SWITCH Engineering, both at the factory and in the field, is to supply the precision switch which most exactly meets the design requirement.

Shown here are just a few recent MICRO SWITCH developments that designers have found useful in a wide variety of applications. Write to any branch office or to Freeport, Illinois for more detailed information.

The Single Actuated Dual Switch consists of two basic switching units operated by a roller lever actuator. The operating point of one of the basic switches is field adjustable so either simultaneous actuation or a definite sequence of operations is possible.

The Illuminated Push Button Switch is a low force, high pre-travel switch with an indicating light as an integral part of the push button. The high pre-travel permits movement of the button before the contacts snap over. This switch is designed for use in electronic, aircraft, mobile, marine, railway and other low voltage a-c or d-c applications.

The High Temperature Basic Switch is a precision snap-action switch which will operate satisfactorily in a temperature range of from −50° to plus 1000° F. It is useful in such industrial applications as found in distilleries, foundries, vulcanizing plants and other industries which require high temperature components.

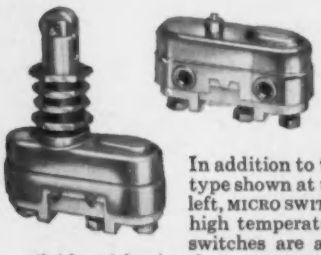
Push Button Actuators are of a new series available to designers of electrical computers and other types of commercial and industrial devices which require reliable panel-mounted, manually-operated switches. They are available with ½″ or 1″ buttons and combine attractive appearance and extremely long life with an exceptionally good actuation "feel".

Manufacture of precision switches is not a side line with MICRO SWITCH. It is our entire *business*. That is why industrial designers come to us more and more each year with switch problems of amazingly diverse types. MICRO SWITCH branches are conveniently located to serve you.

Illuminated Push Button Switches allow mounting on one inch centers

MICRO SWITCH Illuminated Push Button Switches are outstanding for ease of operation, high pre-travel, compact design (which permits mounting on one inch centers), smooth appearance and easy-to-see pilot light. Switches are provided with sockets for a single contact miniature bayonet lamp. Removable translucent push buttons are available in clear, red, or frosted white.

High Temperature Switch comes in three actuator types



In addition to the type shown at the left, MICRO SWITCH high temperature switches are also available with pin plunger actuators for use where space is limited and small operation motion is available and roller plunger actuators for applications where cam or slide action is required.

How Push Button Actuators are mounted to a panel

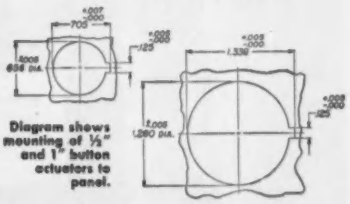


Diagram shows mounting of ½" and 1" button actuators to panel.

Knurled bushing assembly is inserted through the panel and threaded into the switch mounting bracket. The mounting bracket in turn is keyed to the panel, using Mounting details A or B.

MICRO SWITCH Engineering Service is available to help you select the exact switch to meet your design problem. Call the MICRO SWITCH branch nearest you.

MICRO SWITCH

A DIVISION OF MINNEAPOLIS-HONEYWELL REGULATOR COMPANY

In Canada, Leaside, Toronto 17, Ontario • FREEPORT, ILLINOIS

'dag' dispersion stops scoring during run-in of light-weight compressor

Early in the production phase of a new light-weight aluminum compressor for the high-pressure pneumatic systems of aircraft, engineers of Walter Kidde & Company, Inc., Belleville, N. J. realized that special attention would have to be given to lubrication during run-in of the units. Tests of initial models showed that since oil film didn't have a chance to build up during the first few moments of run-in, pistons and cylinder walls were scored. This resulted in a high reject rate and expensive refinishing operations on first-stage pistons.

Kidde engineers have solved the problem by spraying finished pistons with undiluted **'dag'** Dispersion No. 213 before assembly of the units. The microscopically fine particles of colloidal graphite, dispersed in epoxy resin, form a tenacious bond with the metal surface after baking—provide a *dry lubricating film* that will not rub off during assembly and which prevents scoring and seizure during compressor run-in.

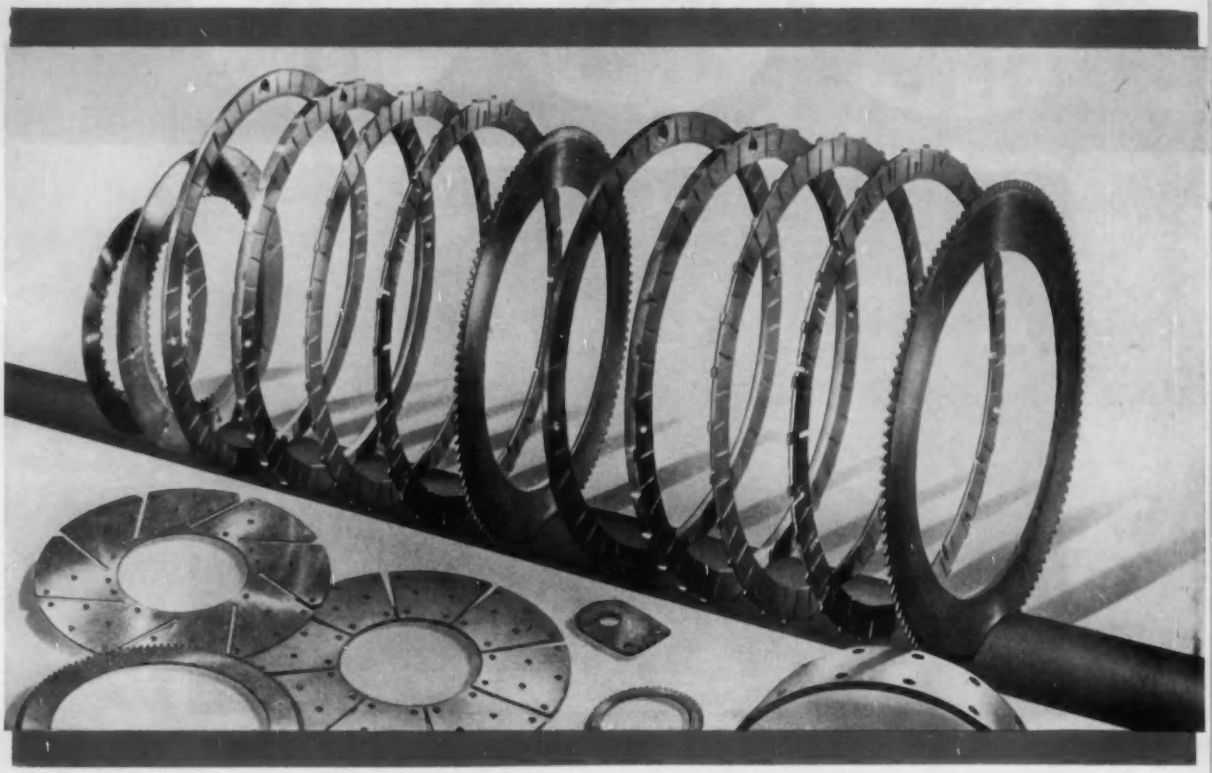
There are many other ways in which the dry-film lubrication provided by **'dag'** dispersions can help in the design and operation of all sorts of mechanisms, from toasters to turbines. Write for full information on **'dag'** Colloidal Dispersions for Dry-Film Lubrication.

Dispersions of molybdenum disulfide are available in various carriers. We are also equipped to do custom dispersing of solids in a wide variety of carriers.

ACHESON COLLOIDS COMPANY
PORT HURON, MICHIGAN
... also ACHESON COLLOIDS LIMITED, LONDON, ENGLAND

use 'dag' dry films for trouble-free lubrication

CALL ON R/M ENGINEERING SERVICE



R/M SINTERED METAL FOR HEAVY DUTY FRICTION JOBS

Wherever high heat, close tolerance, or rapid repetitive engagement is a factor in friction-material performance, Raybestos-Manhattan sintered metal friction parts may give you greater output and greater durability.

Speaking generally, sintered metals are most useful where K.E. absorption per square inch of friction material is very high. Under such conditions, R/M sintered metal friction parts will give better performance because of their high thermal conductivity and absence of a destructible bond.

Remember, however, that sintered metals are intended to *supplement* asbestos molded and woven lines—not *replace* them. That's why R/M, leader in both the asbestos and metal fields, is in an ideal position to help you. R/M works with *all* kinds of friction materials. So when you consult an R/M engineer you are sure of a completely unbiased recommendation as to which materials are best for your particular application.

If friction material performance could be improved in your applications, consult R/M now. All the depth and breadth of R/M experience in friction—the facilities of R/M's seven great plants with their research and testing laboratories—are as near as your telephone.

Write for your copy of R/M Bulletin No. 500. It's loaded with practical design and engineering data on all R/M friction materials.

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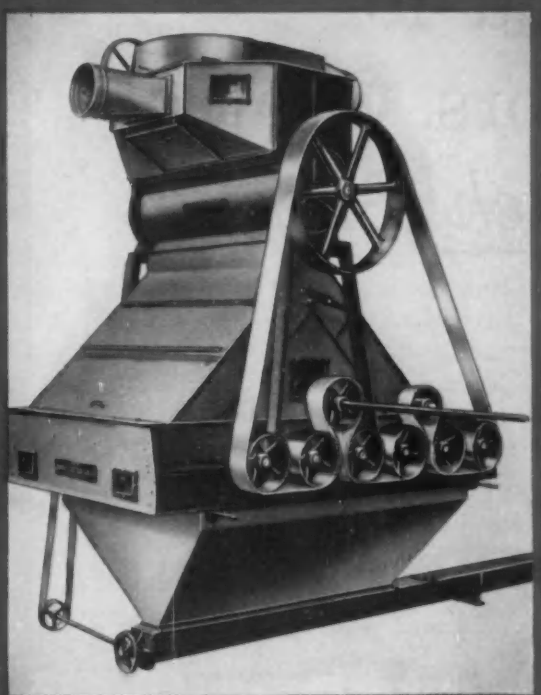

TRANSMISSION BELTS CONDOR WHIPCORD ENDLESS BELT

As an all-purpose belt for use on all types of endless drives, the Condor Whipcord Endless Belt offers exceptional advantages for tough drive designs—small pulleys, reverse bends, small take-up, short centers, high tension, heavy loads, and high speeds. It is made with strong endless-wound cord, is extremely flexible, and will not stretch or shrink on the drive . . . because it is virtually unaffected by atmospheric conditions. The "Extensible-Tip," an exclusive cover end splice design helps Condor Whipcord Belt outlast 3 to 10 ordinary belts on many drives. Let R/M specialists work with you if your machine design calls for transmission belts, Poly-V Drives, V-belts, conveyor belts, hose or molded rubber or Nylon parts.

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PACKINGS, GASKETS ASBESTOS TEXTILES and "TEFLON"* PRODUCTS

R/M packings do an outstanding job of lengthening equipment life and lowering maintenance costs. One reason is their superior lubrication. Locked in during manufacture, the lubricants are all through the product. Heat can not dissipate them. Pressure can not force them out. If you have a packing problem, call on R/M's specialized packing engineering service. R/M makes a complete line of mechanical packings—including Vee-Flex, Vee-Square, Universal Plastic, and "versi-pak."® It can also meet your requirements for asbestos textiles and "Teflon" products.

**Du Pont trade mark*

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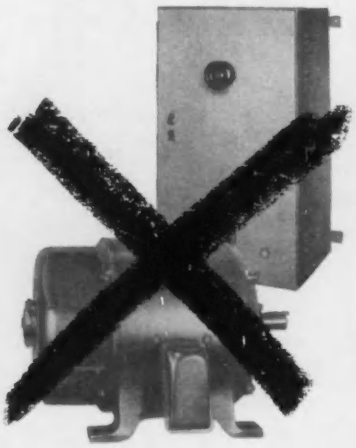
No need for Special Motors, Control with *Vari-Pitch* Sheaves



***Vari-Pitch* sheaves are the low cost way of providing accurate stepless speed control. There's a type and size for every need.**

Two Basic Types

1. Stationary control type can be used for infrequent speed changes when sheave is at rest.

2. Motion control type is available for applications requiring repeated speed changes while drive is in motion.

Both types are available in standard range sheaves to provide speed variations to 196%, and in wide range type sheaves to provide variations to 400%.

For complete information

call your nearby A-C office or distributor — or write Allis-Chalmers, General Products Division, Milwaukee 1, Wisconsin. A-4843

Texrope and *Vari-Pitch* are Allis-Chalmers trademarks.

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Whatever your hydraulic or pneumatic packing needs may be, Houghton has the packings to do the job. And you can get all the engineering help you need, too. Just call in your Houghton Man or write, stating your problem. Houghton hydraulic engineers are located in all principal industrial areas, ready to serve you. As a starter, send for one or all of these latest technical bulletins on the complete line of Houghton VIM leather and VIX-SYN rubber packings. E. F. Houghton & Co., 303 West Lehigh Ave., Philadelphia 33, Pa.

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Homogeneous rubber—precision engineered, withstand a wide range of temperatures and pressures.

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Homogeneous rubber—uniform, fine grain, dense . . . for pressures to 5,000 psi.

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Homogeneous rubber—accurately formed lips, low friction . . . for pressures up to 2,000 psi.

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Ready to give you on-the-job service . . .

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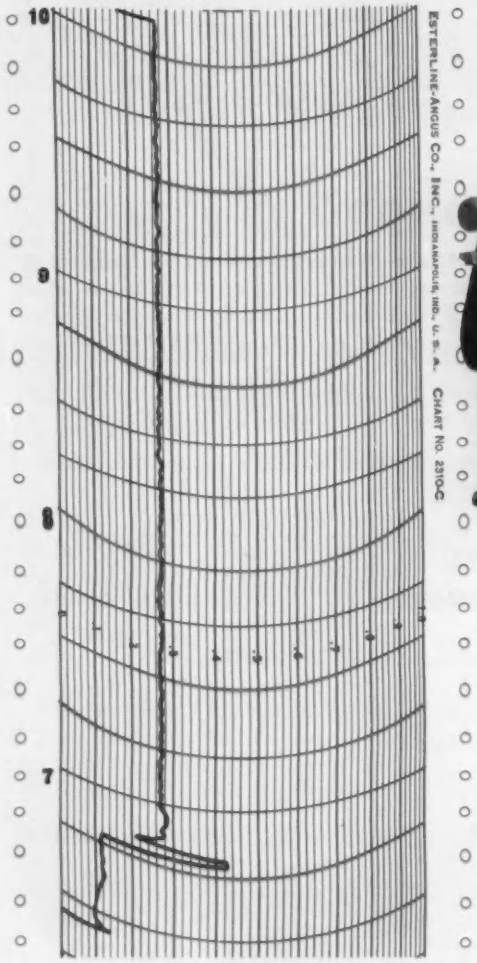
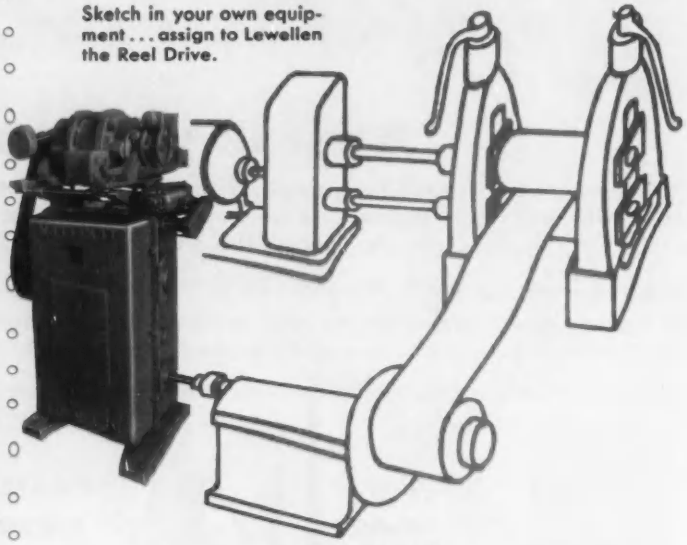


Sketch in your own equipment . . . assign to Lewellen the Reel Drive.



RESULTS

- No buckling
- Straight edge
- Uniform finish
- Uniform caliper
- Level, flat sheet
- Uniform grain structure

Size 114, class F, Lewellen V/S Transmission with Lewellen servos, including dynamometer mounting of 10 H.P. motor, drives reel block for finish rolling mill.

One-third mile of phosphor bronze stock is reeled in 3½ minutes. Reel block speed is slowed automatically at precisely the rate to maintain controlled constant tension, as the chart indicates. Lewellen provides infinitely variable speeds—sensitive and responsive to critical control—manual or automatic.

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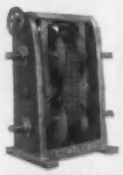

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LEWELLEN MANUFACTURING CO.
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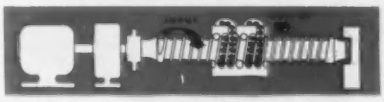
Solve your critical positioning problems with the

SAFETY ball/bearing SCREW!

Typical miniature *Safety b/b Screw* especially engineered for electronics application. Length: 3 inches; weight: 2½ ounces. Other units have been built as short as 1½ inches.

Compact, "flyweight" design . . . hairbreadth precision . . . zero torque . . . "fleapower" operation . . . unprecedented efficiency and dependability make these units ideal for positioning controls in transducers and similar applications



Operating on a remarkably small amount of power because of its 90% to 95% efficiency, the *Safety ball/bearing Screw* can translate rotary to lineal motion (or vice-versa) far *more efficiently than any other type of mechanism known.* Instead of *sliding*, mating surfaces *glide* on steel balls recirculating in closed-circuit raceways.

In many types of electrical and electronic equipment where space and weight are at a premium and the positioning of controls must be precise, the *Safety b/b Screw* has proved the perfect solution.

BOTH ROLLED-THREAD AND MACHINE-GROUND TYPES AVAILABLE

Rolled-Thread *Safety b/b Screws* are available in a choice of 7 standard ball-nut sizes and practically any screw length. They are competitive in cost with standard Acme screws, yet will function 4 to 5 times more efficiently. Where the ultimate in precision and dependability is required, Machine-Ground *Safety b/b Screws* are individually engineered for each specific application. We have built highly successful units

FROM 1½ IN. TO 39½ FT. IN LENGTH

EXCLUSIVE SAGINAW ADVANTAGES

Saginaw pioneered the ball-screw principle in America, was the first volume producer, has both superior know-how and production facilities. In addition, *Safety b/b Screws* offer three basic design advantages:

1. FAIL-SAFE MULTIPLE CIRCUITS — no drone or spacer balls. Saves weight, assures more dependability.
2. GOTHIC ARCH GROOVE DESIGN — permits closer lash control, smoother operation, decreased ball stress.
3. YOKE DEFLECTOR — eliminates possibility of jamming as balls enter return tube—an added safety factor.

WORLD'S FIRST BALL-BEARING SPLINE!

Utilizing the same basic *gliding ball* principle, Saginaw has developed the *Safety b/b Spline* which radically increases the efficiency of transmitting or restraining high torque loads.

Averages 40 times lower friction coefficient than sliding splines!

It can be fitted with integral gears, clutch dogs, bearing and sprocket seats, etc., for use with a wide variety of electrical units. AVAILABLE IN ALMOST ANY SIZE. (Units have been engineered as small as ⅛ IN. IN DIAMETER.)

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? ? 6 sizes in 2

of course!

Rivett Model 6655 Solenoid Controlled, Pilot Operated, Panel Mounted, Hydraulic Valve.

Rivett Panel Valves

feature interchangeable sizes

By changing pipe tap size in steel subplate, the 1″ basic valve may be used for either ⅜″, ½″, ¾″, or 1″ I.P.S.; and the 1½″ basic valve for 1¼″ and 1½″.

CORRECT SIZE IS ALWAYS AVAILABLE

See Rivett Valves at Booth 324 ASTE Show, Chicago, March 19 — 23.

The Better You Know Hydraulics— The Better You Like

and here's another important feature!

GREATER FLOW CAPACITY

Flow capacities are rated at a higher G.P.M. at less velocity per ft. per sec. For example: the 1″ size is rated at 28 G.P.M. at 15 ft. per sec.

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MOTOR DESIGN
INDUSTRIAL QUALITY

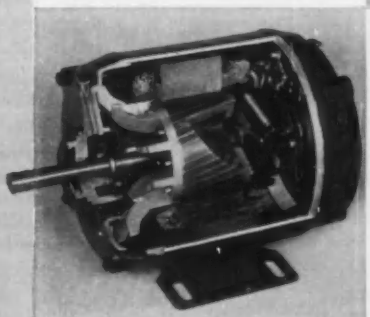
Everything you asked for and more. Smaller, yes . . . and better, too. Here is traditional Century dependability, smooth-running and quietness under load . . . now skillfully engineered into the compact new "48-Frame" design.

These great new Century "Industrial Quality" motors are now available in sizes from 1/20 to 1/3 H.P. . . . developed specially for industrial users.

SEE A SAMPLE of the New Century "48-Frame" motor . . . test one in your plant. Your Century representative will be glad to show you a graphic point-by-point comparison to answer any specific questions you might have. Let him show you how the smaller, lighter and *better* new Century "48-Frame" design gives you true *industrial* quality. Call or write your nearby Century District Sales Office or Authorized Distributor.

We Invite Your Comparison of...

engineering—Weight savings up to one-third are made possible without "skimping" on the vital "active materials," simply by eliminating dead weight and using new materials. The result is smaller-diameter motors that are not merely "just as good" but actually superior to the famous Century "56-Frame."



compare design—For time-saving maintenance, "GITS"-type oilers for sleeve bearings are placed high on the end-brackets, allowing easy oiling from either end of the motor . . . cluster-type integrally cast fan at the rear end of the rotor draws a steady stream of cooling air over the coilheads . . . "Square" stator iron permits air to pass between the core and shell, cooling the whole width.

compare materials — Genuine bonded "MYLAR" slot insulation is used . . . wound cores are dipped and baked in thermosetting insulating varnish . . . GLASTIC high arc resistance switch-mounting plate . . . light and strong, *stress-relieved* pressure-cast aluminum end-brackets, which machine true and *stay* true.

-55

Performance Rated©
MOTORS
1/20 to 400 H.P.

CENTURY ELECTRIC COMPANY

1806 Pine Street • St. Louis 3, Missouri • *Offices and Stock Points in Principal Cities*

announcing Accopac N-820:

a dense fiber gasket for high bolt loads at temperatures up to 250°F.

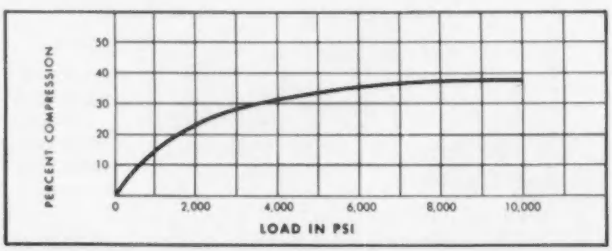
Accopac® N-820 is a new beater-saturated gasket material designed for applications where a combination of heat and pressure may cause conventional plant fiber materials to fail. For example, N-820 is an economical replacement for sheet asbestos packing in applications involving bolt loads of 2,000 psi and upward and where temperatures do not exceed 250° F.

Here's why N-820 can be used successfully in these tough jobs:

High density: N-820 is much more dense than previously available fiber sheets. It withstands test pressures up to 100,000 psi without crushing. N-820 conforms well to flange surfaces and maintains torque much better than softer materials saturated by ordinary methods.

Non-extractable binder: N-820 has no volatile binder which could be lost at temperatures up to 250° F. Its sealing properties are not affected by the leaching action of contained fluids or by alternately wet-and-dry applications. Shrinkage due to binder loss is eliminated with N-820.

N-820 is the newest member of the Armstrong Accopac family, and it's already being used in many heavy-duty applications in place of more expensive materials. If you'd like more information about Accopac N-820, write for samples and data sheet to Armstrong Cork Co., Industrial Division, 7002 Irvin St., Lancaster, Pa.



COMPRESSIBILITY. N-820, less compressible than other Accopac materials, is recommended for heavy-duty applications where flange pressures will be 2000 psi or more and where temperatures do not exceed 250° F.

Armstrong ACCOPAC

. . . used wherever performance counts

DOW CORNING CORPORATION

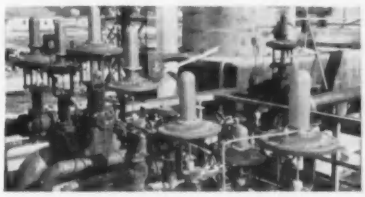
Silicone News

FOR DESIGN ENGINEERS No. 23

SILICONE VALVE LUBRICANT SEALS, PREVENTS CORROSION

In the process industries including refineries, petrochemical and plastic manufacturing plants, Dow Corning Valve Seal A improves the performance and increases the life of valves handling a variety of corrosive chemicals and gases. Effective at temperatures from —40 to 500 F and highly resistant to many chemicals, this silicone lubricant provides a durable seal against leakage of process fluids, and protects valve stems against corrosion.

In fact, Dow Corning Valve Seal A has proved so dependable in such service that Foxboro Valve engineers now offer their Stabilflo line equipped with an isolating valve and lubricator for injecting the silicone lubricant. Excellent results, particularly in reduced maintenance, have been obtained with silicone lubricated



Stabilflo valves handling steam, water, oxygen, gasoline, light hydrocarbons, natural gas, chlorine, hydrochloric acid, cold sulfuric and nitric acids, and ammonia. Trial samples of Dow Corning Valve Seal A are available from any Dow Corning office. *No. 229*

ELECTRIC WHEELS IN HUGE "SNO-FREIGHTER" POWERED BY SILICONE INSULATED MOTORS

The many advantages of placing the power unit close to the work are being realized through the use of heat-stable Class H electrical insulation made with Dow Corning Silicones. A recent example is the silicone insulated motor in each of the electric wheels on the giant "Sno-Freighter" built by R. G. LeTourneau, Inc. of Longview, Texas.

Long-time leader in the development of huge rubber-tired tractive equipment for construction and military use, LeTourneau built this 274 ft. over-land train to provide winter-time freight service between isolated sections of Alaska. Designed and built in only six weeks, the train has a load capacity of 125 tons. Its enormous tires distribute weight broadly so the entire train maintains positive traction on frozen rivers and bays, up icy grades and across rough Arctic terrain.

Each of the 24 wheels on the "Sno-Freighter" is individually driven by a silicone insulated d-c motor located in the tubular axle, and connected to a gear train in the wheel hub. Silicone insulation was specified to give maximum power per pound and reliability under adverse operating conditions. *No. 228*

Silicone Fluid Expands Market for Automatic Conveyor Cutoff

You can obtain more reliable and more efficient performance and at the same time expand the market for many hydraulic control and damping devices simply by using Dow Corning 200 Fluid as the fluid medium. The automatic conveyor cut-off device engineered by Williams Co. of Kansas City provides an excellent example of the plus values imparted by these stable silicone fluids.

This unit prevents overloading and breakdown of belt and screw conveyors and conveyor drive equipment by stopping them the instant a jam or overload threatens. The motion of a moving belt or shaft is transmitted to a revolving case containing a few ounces of Dow Corning 200 Fluid. The fluid is forced against a vane which controls a mercury switch. If motion stops, the vane drops back and trips the switch cutting off power immediately.

(continued pg. 2)

CLASS H MOTOR STILL ON TEST AFTER 54,274 HOURS AT 240 C

At 10 A.M., June 6, 1946, a Class H insulated 5 hp motor was generator loaded to operate at its test temperature of 240 C in Dow Corning's motor test labs. Every 500 hours since it has been shut down and exposed to 100% relative humidity for 24 hours. As of 11 A.M., January 1, 1956, this motor was still on test after 54,274 hours at an average copper temperature of 240 C! That's equivalent to 330 years operation at the Class H temperature of 180 C.

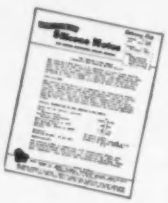
FOR DATA RELATING TO THESE ARTICLES, CIRCLE REFERENCE NUMBER IN COUPON ON NEXT PAGE

MORE

DOW CORNING CORPORATION

Silicone News

DOW CORNING PUBLICATIONS ON NEW DEVELOPMENTS AND TECHNICAL DATA . . . .



Silicone Additive Creates Hammer Finishes. Dow Corning F-4290, effective in the range of 0.1 to 1 part based on the total formulation, is easily incorporated with such vehicle resins as coconut or soya alkyd-melamines, epoxies, silicones, and acrylic or nitrocellulose lacquers. *No. 233*

Documentary film "What's a Silicone?" available free of charge for showings to technical audiences in every industry. In full color and sound, this dramatic 16mm film allows you to see Dow Corning Silicones in action improving the performance of products ranging from nursing bottle nipples to diesel locomotives. For more information about this educational film and how to arrange a showing for interested persons in your plant, circle *No. 234*

"Silicone Glass Parts by Vacuum Laminating" a reprint from MATERIALS AND METHODS, gives detailed procedures for making short runs of oversize, complex, or experimental parts without the expense of production molds; is supplemented with several illustrative photos. *No. 235*

Temperature Stable Pressure Sensitive Silicone Adhesives that stick to almost any material, can be applied and retain useful bond strength at temperatures from —100 to 500 F. Uses include bonding silicone treated electrical insulating materials and as a temporary bond to facilitate assembly of small parts prior to mechanical installation. *No. 236*

"How to Use Dow Corning 44 Grease in the Bearings of Electric Motors" gives suggestions on lubricating open or single shielded ball bearings, double shielded and cartridge type bearings. The recommendations are designed to increase the life of both bearings and motors. *No. 237*

Now available—1956 Reference Guide to Dow Corning Silicone Products. A concise, comprehensive, 12 page reference that is convenient-to-use. It's packed with data, properties, and information on how you can use silicones in designing new equipment, improving performance and reliability of original equipment, or reducing production and maintenance costs. *No. 238*

SILICONE LAMINATED PANEL BOARD IMPROVES ELECTRONIC DEVICES

Based on laboratory and field testing, Schlumberger Well Surveying Corporation now uses a silicone-glass laminate instead of bonded mica sheeting and phenolic laminates as the panel board material in many of their electronic oil well surveying instruments. Here are some of the reasons for this selection.

Schlumberger found that the silicone laminate has more uniform dielectric properties than either mica bonded sheeting or phenolic laminates. Its stability at oil well temperatures is comparable to that of the mica sheetings. Furthermore, the silicone laminate is not subject to cold flow around the high pressure split rivets used to fasten panel board in instruments; it does not loosen in service as do phenolic or bonded mica panel boards. The silicone laminate is also easier, faster and less expensive to install than the fragile mica sheet.

Another important factor in the selection of silicone laminates is their greater moisture resistance. Moisture absorption of silicone laminate is only 0.02% compared with 2% for the phenolic.

To increase moisture resistance still further, Schlumberger coats all joints and connections in their instruments with a waterproof Dow Corning silicone compound. Applied during both original assembly and field maintenance, this heat-stable compound remains in place at temperatures from —70 to 400 F and protects electronic equipment against moisture and electrical leakage. *No. 231*

NOW . . . SILICONE RUBBER NIPPLES

From traction motors to domestic steam irons — wherever product performance can be improved by rubbery materials that retain good physical and dielectric properties at temperatures ranging from —100 to 500 F—designers are finding new applications for Silastic*, Dow Corning's silicone rubber. Latest example is a nursing bottle nipple molded by Pyramid Rubber Co.

World's leading manufacturer in this field, Pyramid describes Silastic nipples as "the longest-lasting ever made." They withstand repeated boilings; do not swell or soften at sterilization temperatures; and remain tasteless, odorless and unaffected by natural fats and oils in baby formulas.

Silastic stays resilient at 500 F. At temperatures high enough to melt ordinary rubber in a pan father forgot to take off the stove, Silastic retains its shape and resiliency.

During months of hospital testing, Silastic nipples repeatedly lasted 15 weeks and more, or 5 times as long as conventional nipples. They are now an important item in Pyramid's "Evenflo" line. *No. 232*

CONVEYOR CUTOFF *(continued)*

Williams originally designed the conveyor cut-off for installation in grain elevators where temperatures frequently drop to 30 or 40 below zero Fahrenheit. Dow Corning 200 was specified because its room temperature viscosity changes little at these low temperatures and because it is nonfoaming.

Because the viscosity of Dow Corning 200 remains nearly constant over a wide temperature span, however, it made the cut-off dependable for use at temperatures ranging from —40 to 400 F. What's more, the silicone fluid helps to make the unit self-lubricating and explosion-proof. *No. 230*

Dow Corning Corporation, Dept. 0602, Midland, Michigan

Please send me: 228 229 230 231 232 233 234 235 236 237 238

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SILICONE NEWS is published for product design and development engineers by

DOW CORNING CORPORATION — MIDLAND, MICHIGAN

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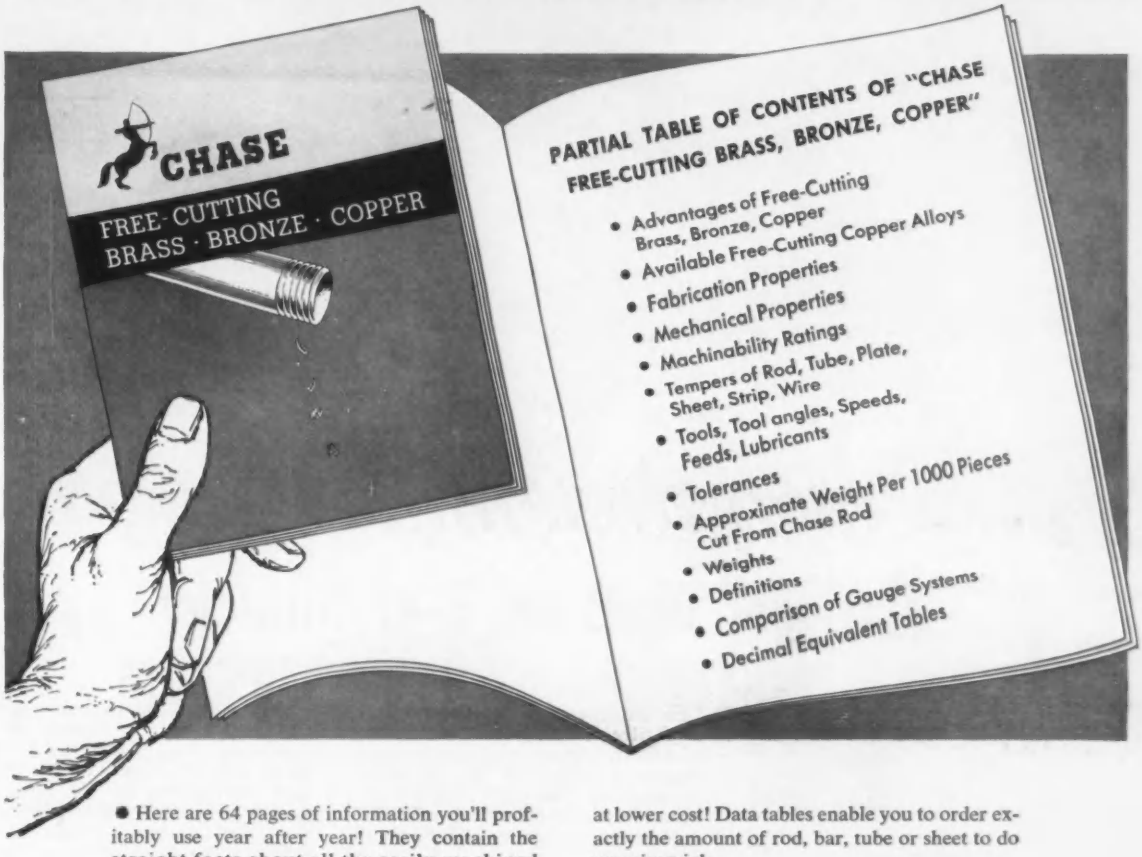
THIS FREE BOOKLET CAN CUT YOUR METALWORKING COSTS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The Boeing B-47—Its six jet engines, each supplying 6,000 pounds thrust, put it in the "600-mile-per-hour speed class." Operating range is more than 3000 miles.

Cold drawn Shelby Seamless Tubes provide *high strength, low weight* outrigger struts for B-47 Stratojet

The landing gear of the 100-ton B-47 Stratojet consists of dual main wheels in tandem with single outriggers attached to the inboard engine pods. The outer cylinder of each of the outrigger struts is fabricated from cold drawn USS Shelby Mechanical Tubing.

Shelby Seamless is extremely strong and shock absorbent in proportion to its weight. Thus, it is ideal for incorporation into landing gears, engine mounts, longerons, wing spars, fuselage struts, and tail assemblies. Moreover, with Shelby Seamless Tubing, *the basic shape* for myriad aircraft parts is already made—and each section of tubing is as sound as the solid steel forging from which it is pierced. Thoroughly uniform and dimensionally accurate, Shelby Seamless Tubing is easy to bend, shape, machine and weld.

Shelby Seamless is produced to exacting aircraft standards, in a wide range of diameters, wall thicknesses and steel analyses. For further information or for help in applying Shelby Seamless Mechanical Tubing to your design specifications, write to National Tube Division, United States Steel, 525 William Penn Place, Pittsburgh 30, Pennsylvania.

"WALLS WITHOUT WELDS," the vivid story of the manufacture of National Seamless Pipe and Tubes is available free of charge for showing to industrial groups, clubs, school groups, etc. This educational sound film in brilliant technicolor contains some of the most dramatic steel mill operations ever recorded. Write for information.

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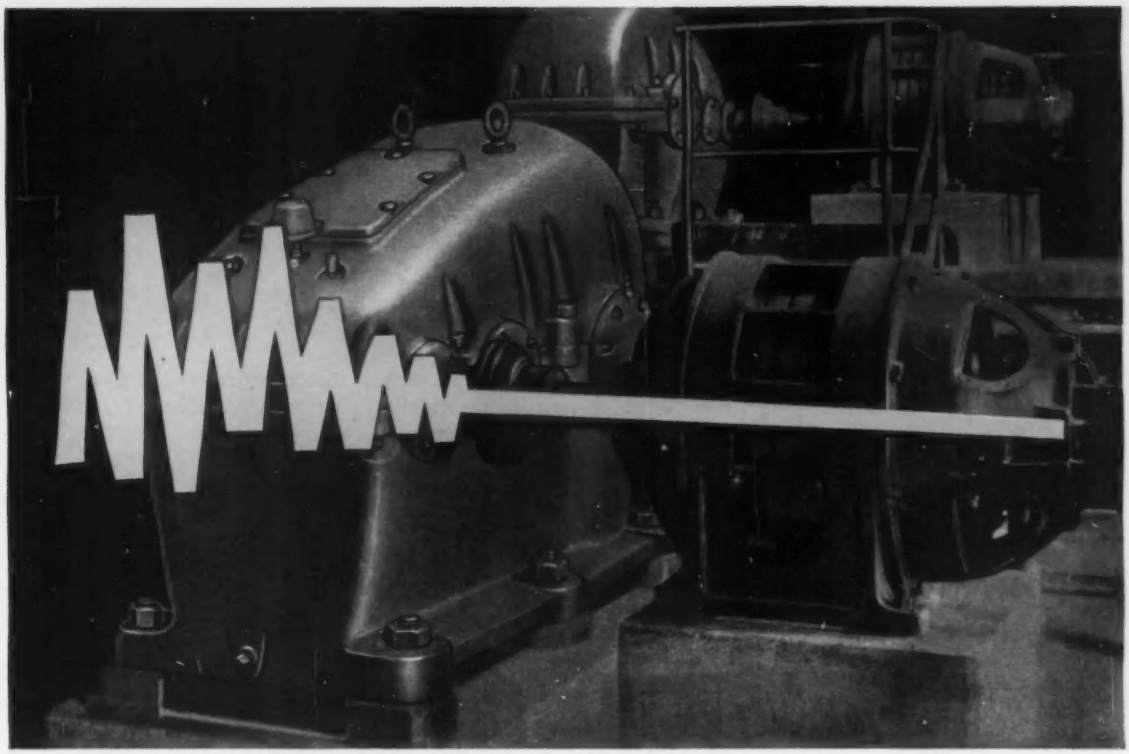
USS

SHELBY SEAMLESS MECHANICAL TUBING

WALLS WITHOUT WELDS

UNITED STATES STEEL



Compact, rugged Link-Belt Parallel Shaft Drive "shrugs off" shock loads. Available with ratios up to 300:1 and horsepower capacities to over 2000.

Rugged LINK-BELT Parallel Shaft Drives

"shrug off" shock loads

WHEN it comes to judging a drive's resistance to shock and frequent overloading, ratings tell only half the story. It's these construction refinements of Link-Belt Parallel Shaft Drives that give you further assurance of long-range speed reduction economy:

GEARS are precision machined, shafts rigidly supported.

BALL AND ROLLER BEARINGS are used throughout.

GREASE-LUBRICATED SEALS block shaft openings to dirt.

AUTOMATIC SPLASH LUBRICATION cuts maintenance.

You'll find, too, that Link-Belt has simplified inspection and maintenance by making all parts accessible without disturbing the base. And to prevent reverse rotation on conveyors, elevators and similar equipment, a built-in backstop can be provided.

There are many more facts worth knowing—as well as specifications and application data — in Book 2619, available from your Link-Belt office. Write today.

Get JOB-MATED drive combinations from the complete Link-Belt line

In addition to parallel shaft gear drives, Link-Belt builds in-line helical and worm gear drives, Gearmotors, Motogears, variable speed drives, fluid drives, chains, sprockets, couplings, bearings, etc. All are pre-engineered for easy installation and maximum efficiency.

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13,955-A

Quick-Opening Fasteners: Screw Type or 1/4 Turn?

Know the features of each before you specify.

M. R. TUOZZO

The selection of a quick-operating door fastener usually involves a choice between two basic designs; the quick-acting screw fastener and the ¼ turn fastener. Both are relatively inexpensive. Each has advantages that make it the logical choice for certain applications.

THE SCREW FASTENER is a rugged, square threaded screw assembly engaging in a special heavy stamped nut. The nut is clipped, riveted, or welded to the door frame. A special washer behind the thread captivates the screw in an oversize hole in the door.

Because of its exceptional "float," it is installed without precision measurements and will always line up with ease. Where a variation in material thickness may occur or a gasket must be compressed, the screw fastener is preferred, since a single grip length can be used throughout. Under most conditions it will completely disengage in two to four turns. It offers excellent resistance to vibration and forms a solid joint with no "give."

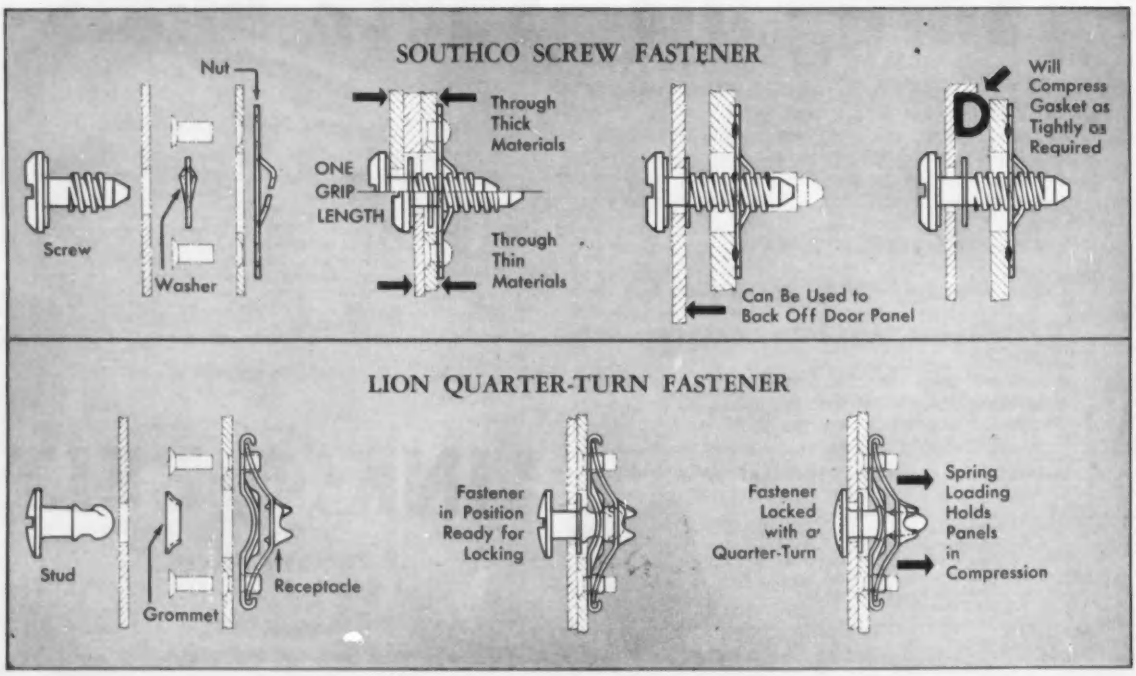
The screw fastener can be backed all the way out of the door frame without moving the door. If required, it can be installed so as to jack the door open as it is unscrewed.

THE QUARTER-TURN FASTENER is usually selected for application on aircraft (under Army-Navy-Air Force specification MIL-F-5591A) where instantaneous removal of fastened parts is required. As the name implies, it is quickly locked or unlocked by a fractional turn.

Its strength characteristics also are very high when the stud is formed from a single piece and no thin springs, wires, or cross pins exist in the assembly. The stud is retained in the door panel by a metal grommet, and engages in a full floating spring-loaded receptacle, riveted or welded to the door frame.

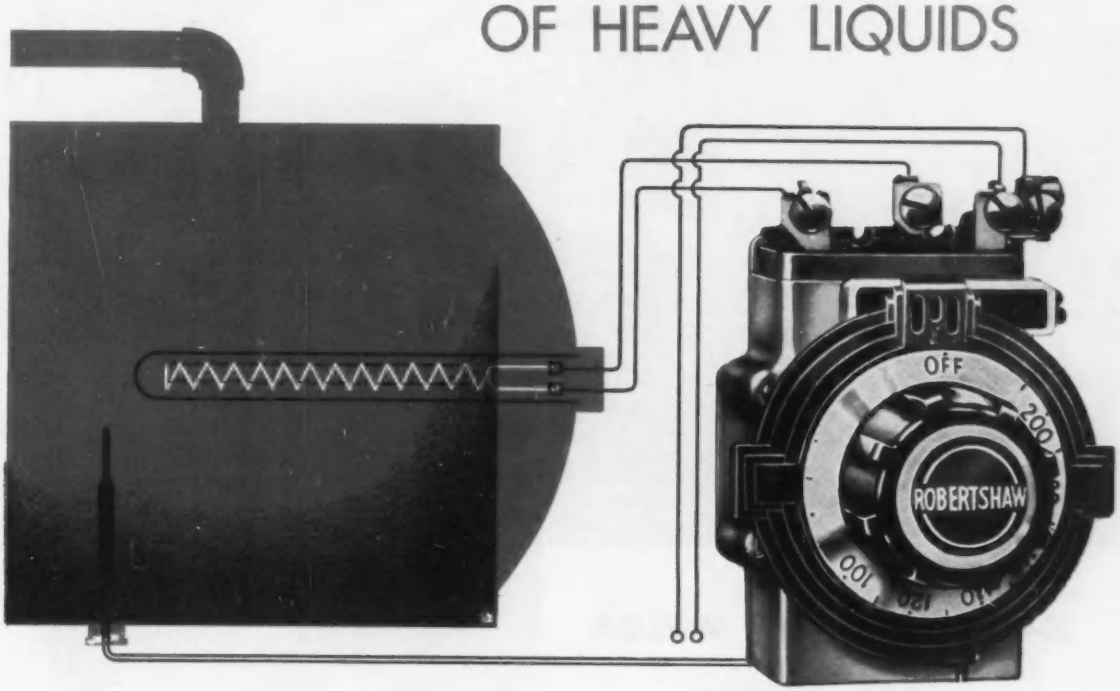
Where the thickness of door and frame are fairly constant through an entire production run, the quarter-turn fastener is a wise choice. Its design affords maximum speed in fastening, and excellent vibration resistance.

COMPARISON OF STANDARD QUICK-OPENING FASTENERS



SOUTHCO Division, South Chester Corporation, 236 Industrial Hwy., Lester, Pa.

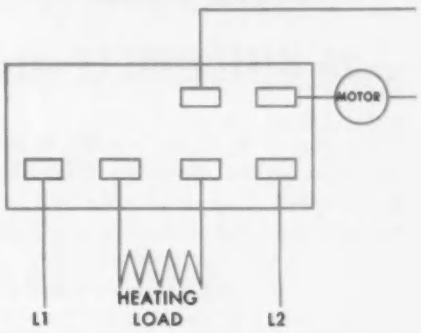
FOR TEMPERATURE AND MOVEMENT CONTROL OF HEAVY LIQUIDS



New double circuit control with thermal delay action

The new F2 is designed especially for the control and movement of heavy liquids where liquid flow or agitation must begin before the liquid temperature reaches the point for maximum ease of liquid movement.

With pumping of heavy fuel oil for example, pumping can be set to begin at 130° while the temperature of the oil continues to rise to 180° for maximum ease in pumping. The F2 controls both temperature and pump or agitator cycle.



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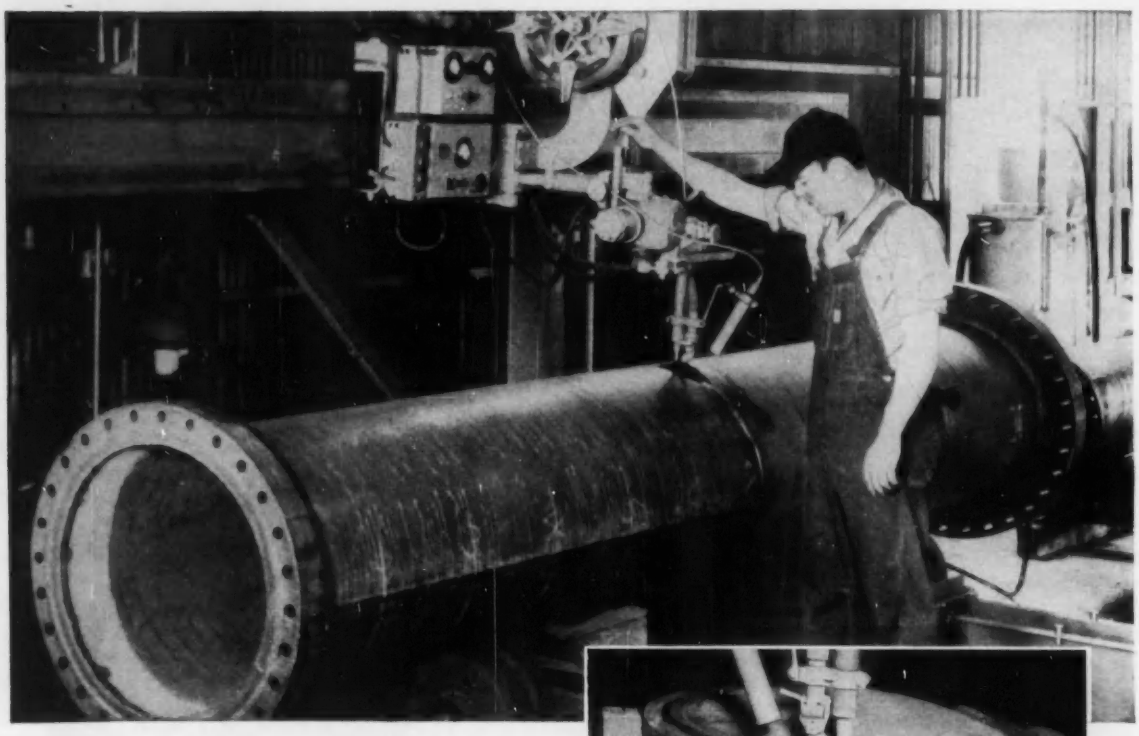

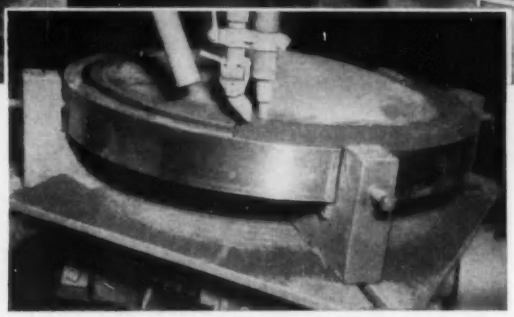

X-RAY-QUALITY WELDS ...75% FASTER *with* UNIONMELT WELDING

Top-quality welds are a must to assure the maximum service life of parts subject to high pressure and temperature. Like many manufacturers of pressure units, the Western Supply Company, Tulsa, Oklahoma is using UNIONMELT welding to make X-ray-quality welds (in heat exchanger shells) at new high speeds.

*** HIGH SPEED:**

UNIONMELT welding speeds average 15 to 19 in. per min.—this is as much as 75 per cent faster than welding methods previously used. The steel parts welded range from ½ to 3 in. in thickness, and welds are made in from one to three passes.

*** REDUCES GRINDING:**

Since UNIONMELT welding produces smooth, flat weld beads, the need for grinding completed welds has practically been eliminated—further reducing production costs.

UNIONMELT welding is the fast, efficient method of fabricating metals thicker than 18 gage. UNIONMELT welding makes possible increased fabricating speeds and lower production costs. Learn the details—call your local LINDE Representative for more information on UNIONMELT welding, and start saving today.

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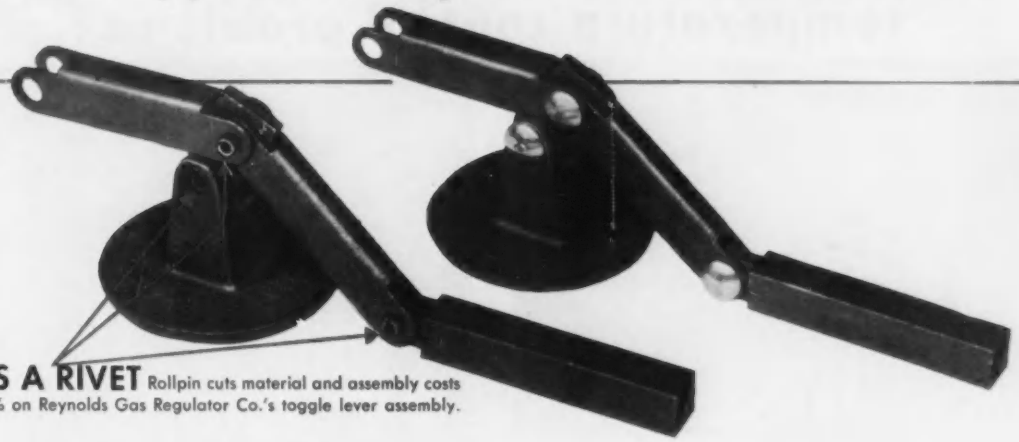
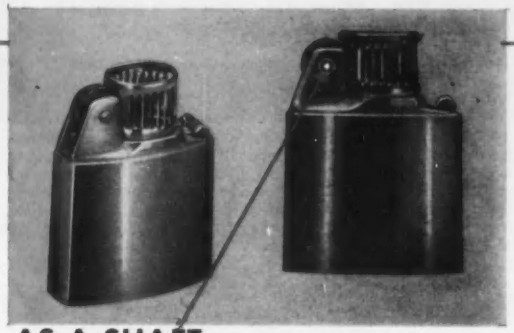
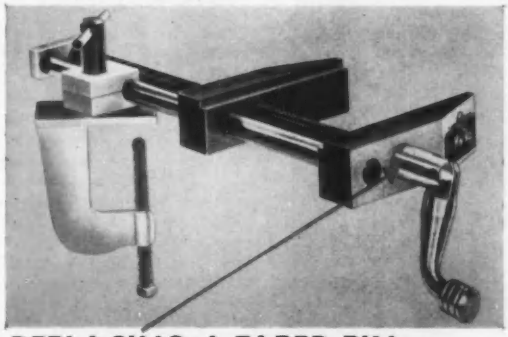
Three typical Rollpin cost reductions



AS A RIVET Rollpin cuts material and assembly costs 25% on Reynolds Gas Regulator Co.'s toggle lever assembly.



AS A SHAFT before and after shot of this Ronson lighter shows how Rollpin made savings of 1½¢ per unit in assembly of spark wheel.



REPLACING A TAPER PIN Rollpin saves 24¢ labor cost on each of American Machine and Foundry's MITY-7-VISES. Eliminates tool cost caused by breakage of small taper reamers.

ESNA® TRADE MARK

ROLLPIN TRADEMARK

Where can you use this simple fastener?

If you use locating dowels, hinge pins, rivets, set screws—or straight, knurled, tapered or cotter type pins—Rollpin can cut your production and maintenance costs as it does in every class of industry. Rollpin is a slotted tubular steel pin with chamfered ends that drives easily into standard holes, compressing as driven. Its spring action locks it in place—withstanding impact loading, stress reversals and severe vibration. No threading, peening or precision drilling needed. Rollpin is readily removable and can be re-used in the same hole.

ELASTIC STOP NUT CORPORATION OF AMERICA

MAIL COUPON FOR DESIGN INFORMATION

Elastic Stop Nut Corporation of America
Dept. R38-22, 2330 Vauxhall Road, Union, N. J.

Please send the following fastener information:

☐ **Rollpin samples**
☐ **Rollpin bulletin**
☐ **Here is a drawing of our product. What self-locking fastener would you suggest?**

Name_____ **Title**_____

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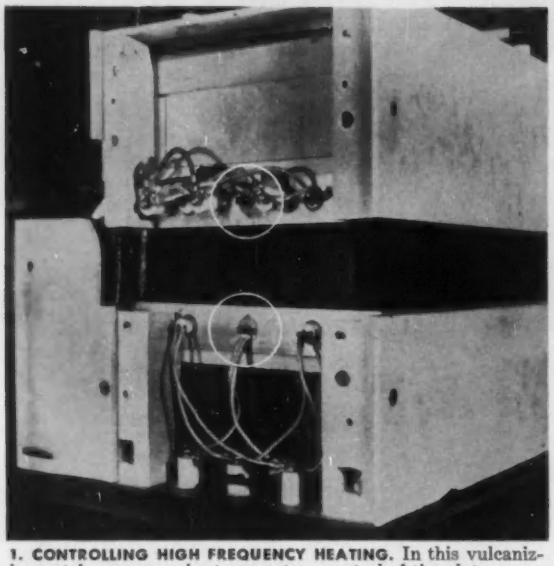
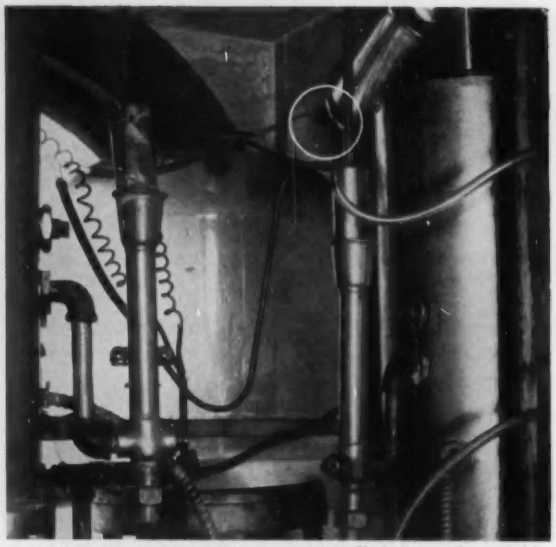
How would you solve these tricky temperature control problems?

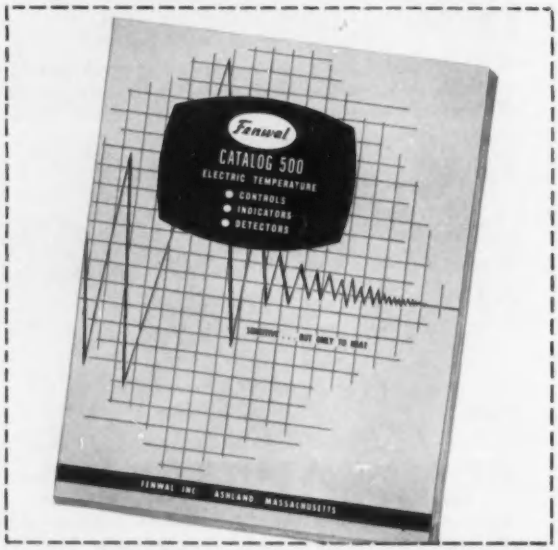


1. CONTROLLING HIGH FREQUENCY HEATING. In this vulcanizing patch press, precise temperature control of the platens was required to prevent loss of electronic heat generated within the processed material. Fenwal's solution was two THERMOSWITCH® units, set at 400F, mounted on the platens. Result: a production rate of 3,000 patches per hour, compared to ordinary hot press methods of 30 per hour.



2. SAFETY IN A DISTILLING PROCESS called for a dependable failure alarm. A Fenwal THERMOSWITCH unit in the condenser's safety vent solved the problem. Now, should the cold water supply fail, steam blowing through the condenser tubes will hit the THERMOSWITCH unit. This control, set at 120F, will then open, shutting off the electric heaters and sounding a continuous alarm.

3. PROTECTING PRODUCTS. In this shoe lining smoother, the problem was twofold: to use the fewest possible thermostats; provide close temperature control in order to prevent burning of shoe leather. Fenwal's solution: a single adjustable THERMOSWITCH unit, mounted on one ironer and controlling two ironers. This halved the number of thermostats indicated, while providing precision temperature control.



4. SEND FOR NEW CATALOG, just off the press. It describes Fenwal's complete line of THERMOSWITCH units and new indicating controllers for industrial applications. Fenwal engineers are always glad to help on any of your temperature control problems. Write **Fenwal Incorporated, 22 Pleasant St., Ashland, Massachusetts.**

Fenwal **THERMOSWITCH®**
Controls Temperature — Precisely

GET STRENGTH, DURABILITY AND LESS WASTE WITH ASARCO CONTINUOUS-CAST BRONZE ALLOYS

You get better parts with longer life . . . tools last longer, too . . . when you use bronze rods, tubes and shapes produced by the Asarco Continuous-Casting process. Asarcon Bronzes are metallurgically superior. Fatigue characteristics are raised 33% to 100% and impact strength is increased from 15% to more than double that of the same alloys produced by other casting methods. Yield strength is up from ⅓ to more than 50%.

Clean-up allowances on Asarcon Bronzes are only 1/32 inch on the smaller sizes and 3/32 inch on the largest. You don't pay for excess casting weight. Machining time is greatly reduced. There are fewer rejects, too, because the Asarco process produces bronzes of exceptional uniformity. Impurities are excluded, alloys are free from porosity, hard and soft spots are eliminated.

And you can order Asarcon Bronzes in mill lengths suitable for automatic screw machine fabrication. Diameters now range from ½ inch to 9 inches in any size you want. Many foundry alloys and a variety of shapes are made to order in all of these sizes. The famous Asarcon 773 (SAE 660) can be shipped directly from stock.

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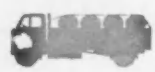
Eliminate diesel service problems in the world market



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Perkins produced over 4,000,000 brake horsepower in light, high-speed diesel engines in 1954. 70% of this output went into the world markets—where Perkins Diesels set the world standard in motors up to 120 B.H.P.

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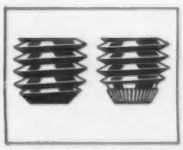
Greater resistance to removal holds Allenpoints tighter in your products

Tests prove that ALLENPOINT Set Screws have 50% HIGHER WITHDRAWAL TORQUE than serrated point set screws

HIGHER WITHDRAWAL TORQUE WITH ALLENPOINTS! In ¼" x ¼" sizes, tightened to shear point of key, Allenpoints required 75 inch-pounds removal torque. Serrated point set screws gave up their hold at only 50 inch-pounds removal torque.



ONE MORE FULL THREAD WITH ALLENPOINTS! Compare, and you'll find that Allenpoints have *one more full thread* than same size serrated point set screws. That means greater holding power, especially in the much-used "square" sizes.

DEEPER, CLEANER SOCKETS WITH ALLENPOINTS! Allenpoint sockets are *"pressur-formd"* to preserve the long fibers of the steel uncut throughout the *entire* length of the screw. This makes a deep socket of maximum strength, in which the key seats with great exactness.

Specify ALLENPOINTS for far greater *holding* power — the kind of fastenings that "stay put". Genuine Allenpoints and other Allen fasteners are available from your Industrial Distributor — standard items immediately, special items very promptly. Write for full information.

You want maximum holding power from every set screw in your product. Here's why you'll get that from ALLENPOINT ○ Set Screws: Allenpoints and serrated point set screws were recently compared in laboratory tests. They were the kind of tests you'd make in your own plant — random samples of each were chosen from regular stock boxes from distributors' shelves.

In each test, keys were tightened right up to the shear point — maximum tightening point for any set screw. In each test, 50% HIGHER WITHDRAWAL TORQUE was required to release the ALLENPOINT ○ Set Screws.

Translated into your own product, this means more dependable fastening with ALLENPOINTS.

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Installation of the most modern equipment, doubling our engineering and other specialized personnel are but some of the factors contributing to our newly increased productivity and efficiency.

Long's experience in quality manufacture includes over a half century of volume production for American industry. The progressive policies of Borg-Warner—of which we are a Division—set new goals in expanding our engineering and production service.

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NEW LONG RADIATOR BOTTOM TANK OIL COOLER

Simply and economically placed in the lower tank of the radiator this new Long-designed oil cooler in one neat out-of-the-way package maintains desired oil temperature for engine and/or transmission. They are available in a variety of lengths, thicknesses and multiple wafers, and are now in volume production at Long.

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Long radiators make the most efficient use of material and provide a more rugged construction at competitive prices. Long's outstanding engineering facilities are available to you for design and building of any type of radiator or heat exchanger.

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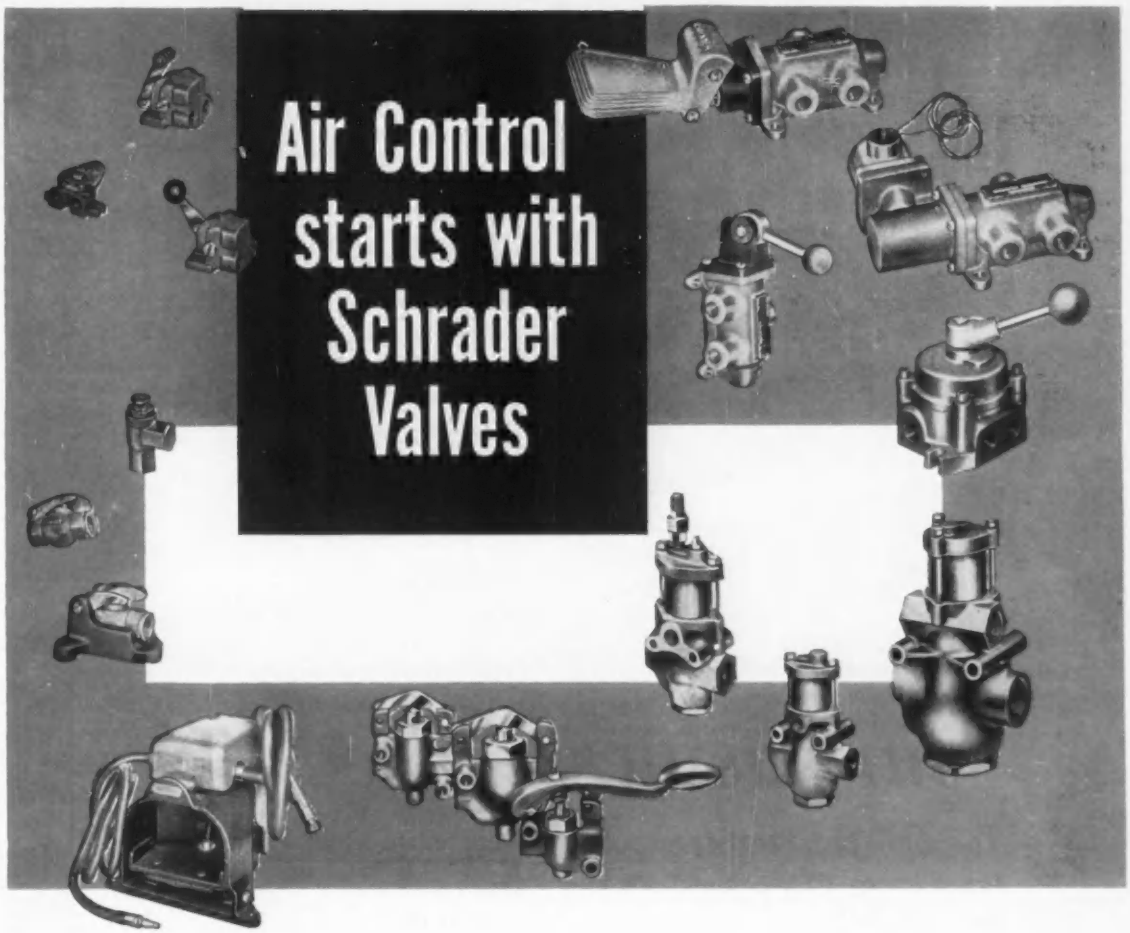

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MANUFACTURERS AND CUTTERS OF WOOL FELTS

B.F. Goodrich Rivnut

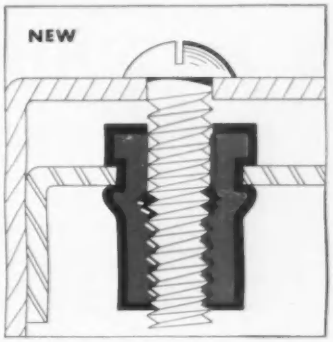
provides shockproof nutplate, saves time and money

B. F. Goodrich Rivnuts provide accurate, shockproof nutplates in one, quick operation. They eliminate nuts, welding, tapping, clinching. They are particularly suited for blind applications where other methods of fastening are impossible. They give a tight, dependable seal. And save man-hours, too, because one operator can install a Rivnut in seconds.

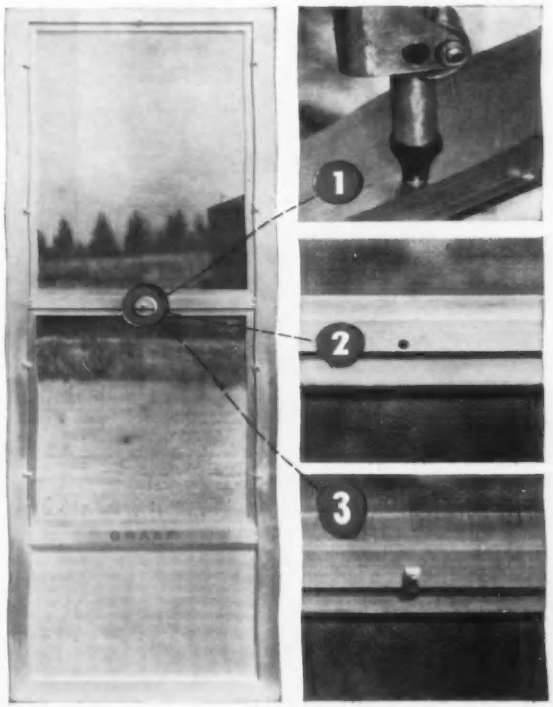
Just as BFG Rivnuts speeded up output and eliminated assembly and service problems for the Graef Storm Window Co. (SEE PICTURES AT RIGHT), Rivnuts are uniquely successful when used in any thin sheet metal. They are the only method of fastening available that gives 6 clean threads for attachment. They can even be installed *after* enameling.

If you're looking for a fastener that can improve your product and cut production time, why not get the help of The B. F. Goodrich Co., Dept. PE-26, Akron, Ohio.

USING SELF-TAPPING SCREWS. To attach insert clips to aluminum storm doors, the Graef Storm Window Co. considered a conventional method, tried self-tapping metal screws. They found that due to the softness of the aluminum, screws pulled out and enlarged the hole. A new hole had to be made or a larger self-tapping screw used. They could foresee service problems. When storm windows were changed by the user, the metal would pull or tear.



USING B. F. GOODRICH RIVNUTS. No assembly problems, no service problems, reports Graef. Rivnuts speed assembly—installing in door stiles takes only seconds. They provide a firm, accurate nutplate that does not loosen with shock or vibration. At least 6 threads are clean for attachment, eliminating any pulling or tearing of metal during assembly or later, when storm windows are changed by the user.



HOW GRAEF SPEEDS ASSEMBLY USING RIVNUTS
(1) Rivnut is inserted in blind aluminum door stile. Heading tool forms bulge inside in one, quick operation. (2) Rivnut fits smoothly, tightly. Six clean threads provide attachment for (3) bolt and retaining clip which holds screen insert. Door slamming, change of inserts will not loosen the nutplate the Rivnut provides.

Send now for

FREE RIVNUT Demonstrator

Demonstrates with motion how you can use Rivnuts to fasten TO and fasten WITH. Explains construction, simplicity of installation. Get your free copy today by writing to: The B. F. Goodrich Company, Department PE-26, Akron, Ohio.

B.F. Goodrich RIVNUTS

The only one-piece blind rivet with threads

Never before on a Power Plane... a motor that spins at 25,000 RPM!

CASE HISTORIES FROM MT. VERNON FILES

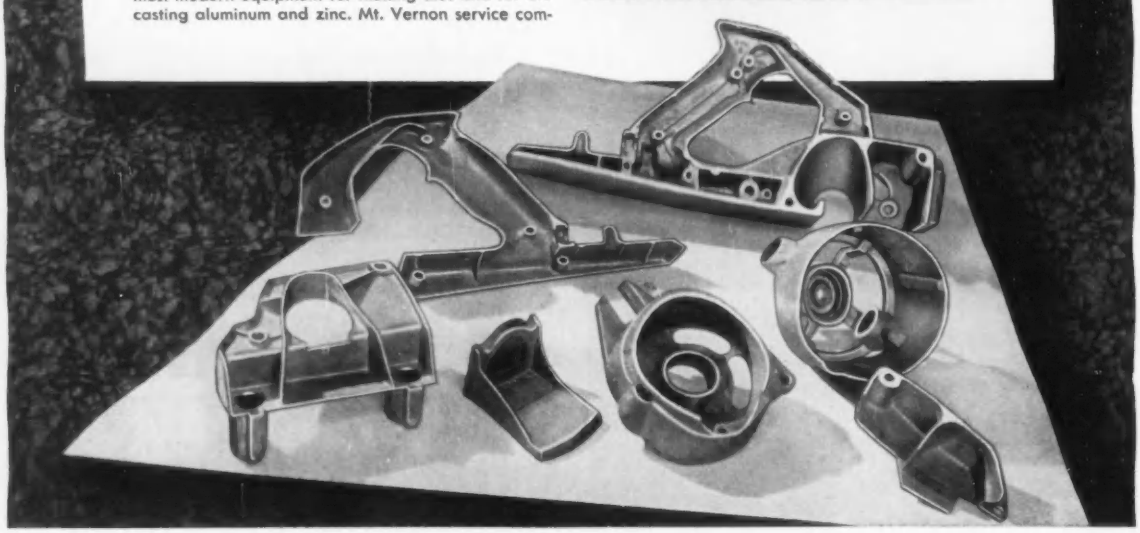
No power plane before this Porta-Plane has ever used such a high speed motor. And when any manufacturer is out to break all precedents, and still sell his product at a low price, he needs every bit of designing and production skill he can find—anywhere.

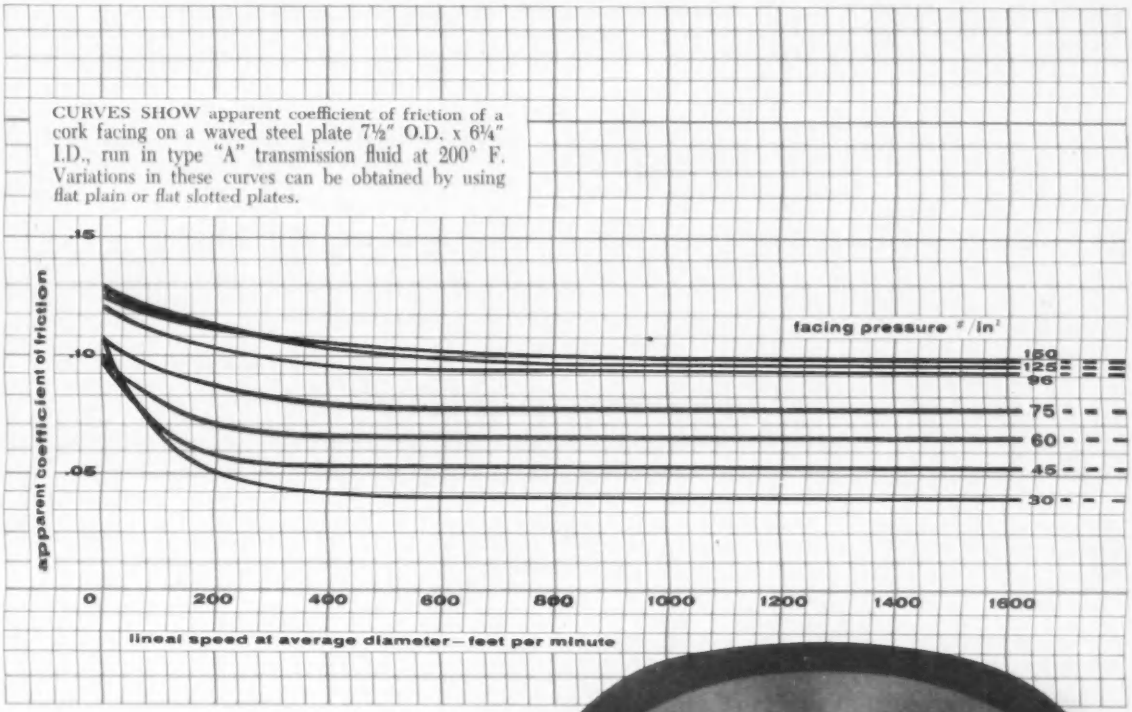
This manufacturer found these in generous abundance at Mt. Vernon. The 8 principal parts of the frame of the Porta-Plane were designed to obtain the special advantages of die casting: thin wall sections of great strength and rigidity, negligible machining, smooth finish, high speed production, low cost.

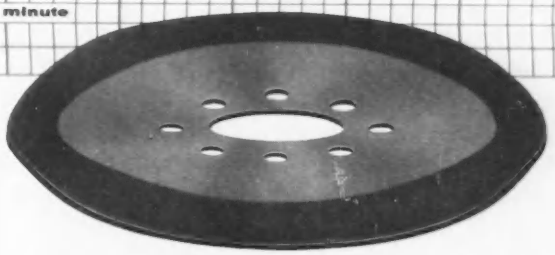
This important advantage—low cost—stems directly from the way we are organized here at Mt. Vernon. From die cast to finished casting, Mt. Vernon has both the complete die casting service and the facilities it takes to produce parts like these at minimum cost in any quantity. We have 162,000 square feet of the most modern equipment for making dies and for die casting aluminum and zinc. Mt. Vernon service comprises completely coordinated designing, die-making, casting, and machining, all under one roof.

It will pay you to bring your production specifications to us. We may show you, as we did Porter-Cable, the way to important cost reductions and improved products.

MT. VERNON
DIE CASTING CORP.
STAMFORD, CONNECTICUT







CORK CLUTCH FACINGS:

How a waved plate affects engagement characteristics

Two of cork's unique advantages as a friction material are its flexibility and its unusually high coefficient of friction when immersed in oil. These two characteristics contribute much toward the wide latitude cork compounds offer designers in wet clutch applications.

For example, by using cork facings on waved plates the designer can control and manipulate the oil film—and thus produce a soft, gradual engagement when desired.

At low pressures, cork facings on waved steel plates apparently ride on the oil film like a Kingsbury Thrust Bearing. As pressure is increased, however, the waved plate flattens—and better contact is made. When maximum pressure is developed, the plate flattens to make full contact, and engagement is completed.

Still other engagement characteristics can be obtained by using a cork facing on a flat steel plate, or by slotting a cork facing, or by varying engagement pressures. Additional data on this subject—along with many helpful charts and graphs—is contained in the booklet shown at the right.

NEW 16-PAGE BOOKLET

For more information on the design versatility of cork-compound friction materials, send for a copy of our new booklet, "Armstrong Resilient Friction Materials." Write to Armstrong Cork Company, Industrial Division, 7202 Irvin Street, Lancaster, Pennsylvania.

Armstrong FRICTION MATERIALS

... used wherever performance counts

ONE OF A SERIES OF INFORMATIVE MESSAGES FROM HYATT . . .

Cylindrical Roller Bearing Retainers . . .

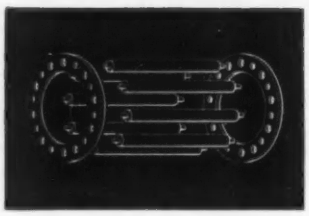
The seven basic types in current use . . . their influence on bearing cost and performance . . . why one type is best suited to your individual design requirements

Most cylindrical roller bearings consist of an inner race, an outer race, a complement of rollers, and a cage or separator which locates and guides the rollers. There are significant differences in the design and construction of these roller retainers. (The word "*retainer*" is used to designate both a cage, which retains the rollers, and a *separator* which only spaces the rollers.) Some retainers are simple and economical, well adapted for volume production, and designed for use where price is a primary consideration. Others are more costly to make but are designed for improved roller guidance, to insure cooler or smoother operation, or to provide longer life in heavy duty service.

Beginning with the most elementary, here are the seven basic types of cylindrical roller bearing retainers in current use, with a brief outline of their construction and characteristics:

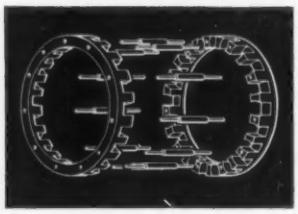
1. TRUNNIONED ROLLER CAGE

The trunnioned roller cage is used for bearings of very thin annulus, where the rollers must be small in diameter, closely spaced, and relatively long. The end rings are economical hardened steel stampings, into which the trunnioned rollers are inserted. The bars which connect the end rings are riveted to the rings at assembly so that the rollers and cage form an integral, non-separable unit. Thus, outer or inner races can be omitted if desired, with rollers operating directly on a suitably hardened shaft or housing bore. This cage is an economical design for volume production and possesses excellent operating characteristics for a wide range of applications.



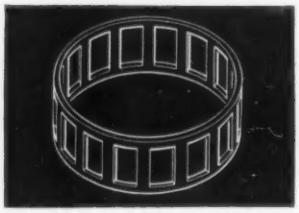
2. POCKETED END RING CAGE

The pocketed end ring cage is restricted to fairly large bore bearings with relatively long rollers. The end rings are bronze. The steel connecting bars are riveted into the end rings and the rollers operate in drilled pockets which guide them accurately. The construction has less tendency to twist or rack, and operates with less end friction because the outside faces of the bronze end rings are smooth uninterrupted surfaces. This type is known as a roller-riding cage, and makes no contact with the bearing races. It can be produced economically in small lots and since it is non-separable, bearing races can be omitted if desired. The characteristics of the pocketed end ring cage make it particularly desirable for applications where long life and heavy-duty service are required.



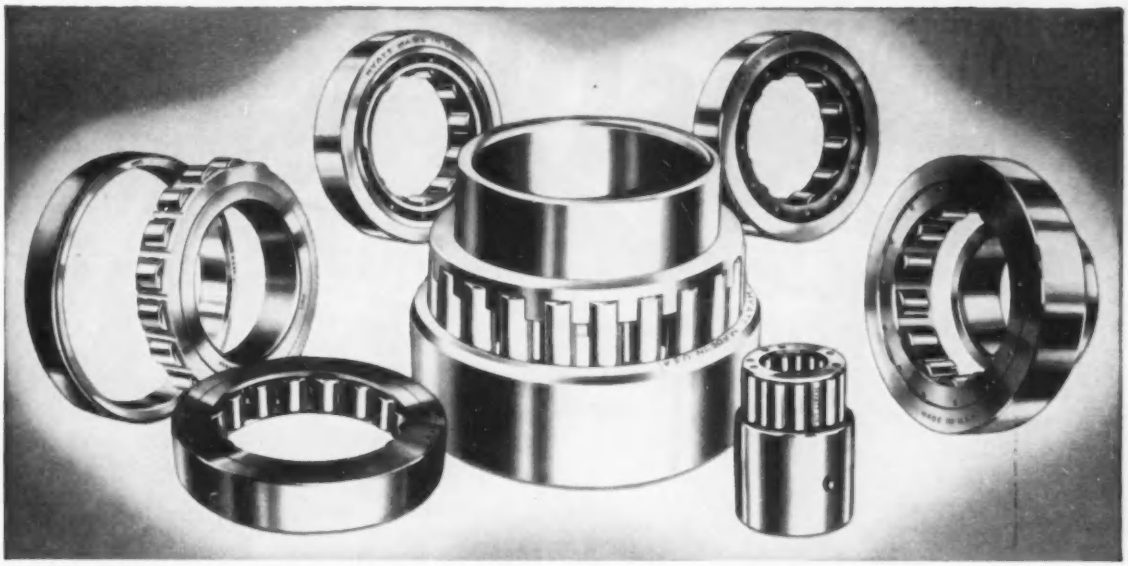
3. STAMPED STEEL SEPARATOR

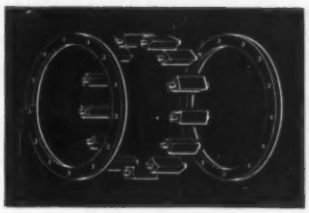
The stamped steel separator does not retain the rollers by itself, but merely separates them. It is a one-piece steel stamping with the separating bars coined to conform to the roller contour, and rides the rollers below their pitch line. Rollers are guided by the race flanges and snap rings, in conjunction with the cage bars. The simple, open design of this separator insures large grease capacity and good lubricant circulation, rendering it relatively insensitive to dirt. Since the separator is retained axially by the roller ends, there is no external requirement for axial location. The stamped steel separator is usable throughout a wide range of bearing sizes where rollers are relatively short (the Hyatt Hy-load series), and is economical for volume production.



4. FORMED BAR CAGE

The formed bar cage is built up of stamped end rings and bars formed to the roller contour. The end rings and bars are riveted together at assembly, making the race and roller assembly a non-separable unit. This cage is used on Hy-load bearings, with double-flanged inner or outer races. This

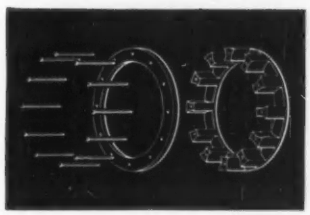




design insures quiet operation, better roller guidance, and provides a smooth contact surface between bars and rollers. This is a roller-riding design requiring no race contact in operation and is well adapted for volume production.

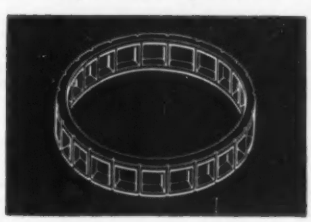
5. DRILLED POCKET CAGE

To construct this type, a bronze cylinder is drilled and reamed to form pockets in which the rollers operate. After the rollers are inserted, a flat end ring is riveted in place so that the rollers are permanently retained in the cage. This design provides extremely close control of the rollers in operation and prevents skewing which would impair both the thrust and radial capacity of the bearing. This is another roller-riding cage comprising a non-separable unit suitable for operation with inner or outer races omitted. The design insures superior performance and is used in applications requiring bearings of better than commercial quality.



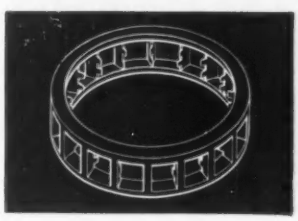
6. SEPARABLE BROACHED POCKET CAGE

This type is used only on the finest-quality bearings where performance is more important than price. It is made of one integral bronze cylinder, with pockets broached for maximum uniformity. This is the preferred type for the finest high-speed precision bearings because it insures minimum friction between rollers and separator, and allows better oil circulation for cooling at high speeds. Moreover, there are no thermal differences in this monolithic construction; the entire unit heats and cools uniformly. The separable feature offers the further advantage of roller removal for inspection of the race operating surfaces.



7. NON-SEPARABLE BROACHED POCKET CAGE

Similar in construction to the above, this design offers all the same inherent operating advantages. It is used in bearings where installation must be "blind," requiring rollers to be retained with the inner or outer race. Controlled roller drop is provided by deforming the connecting bars at assembly after the rollers are in place in the cage. This insures proper retainment but has the disadvantage that the bearing cannot be taken apart for inspection.



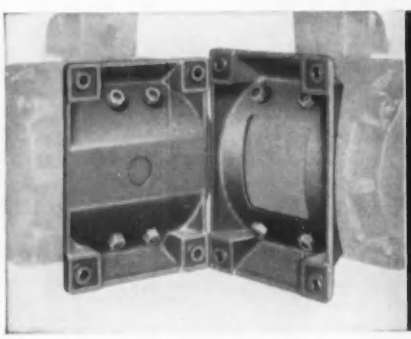
HYATT MANUFACTURES ALL SEVEN TYPES of cylindrical roller bearing retainers described above—each the finest of its type. You will find more details in HYATT General Catalog No. 150, or your nearby HYATT Sales engineer will be glad to help you choose the type best suited to your individual design requirements. Remember, HYATT is America's *first* and *foremost* maker of cylindrical roller bearings. Hyatt Bearings Division, General Motors Corporation, Harrison, New Jersey.

GM GENERAL MOTORS

HYATT
ROLLER BEARINGS

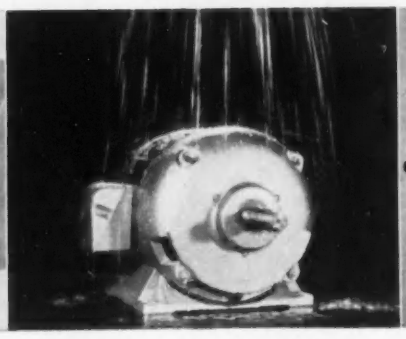
Single-Phase EXCLUSIVE ...totally-enclosed motor switch and actuator... in

You get these quality A. O. Smith motor features...



OPTIONAL FRAME MOUNTINGS

There's no need to change product design to use new NEMA frame sizes. A. O. Smith gives you frame mountings drilled to old and new specifications.



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Motor can be mounted in any position . . . drip-proof thru 360° cycle . . . simply rotate end brackets. No foreign matter can enter vent holes.

PRE-LUBRICATED BEARINGS

Shielded bearings assure protection against over greasing . . . provide even load distribution under all working conditions . . . quiet operating.

A. O. Smith integral hp motors

* Always clean
* Easy to service

THE secret of the totally-enclosed switch assembly is a sealed pocket in the end bell of the motor . . . a recess designed specifically to house the entire switch and actuator assembly. The pocket is then sealed with a cork-lined cover to prevent any type of dirt, dust or other foreign matter from *ever* coming in contact with these critical parts.

Service is a cinch. Because of the proven simplicity of the A. O. Smith switch design, service, even without the separately sealed feature would be practically nonexistent. Each switch is individually adjusted to the precise setting for long life and best electrical performance. As a result, it's almost impossible for contacts to burn out.

When you specify A. O. Smith integrals, you get motors that are application-engineered to match your particular product design. There's no need to adapt your product to the design limitations of conventional motors.

And remember — for your design or speed requirements, there's an A. O. Smith integral hp motor available to power your products. Integrals are built in a single-phase (1 thru 7½ hp) and polyphase (1 thru 150 hp) . . . in various speeds and frequencies . . . choice of frame mountings for either old or new NEMA dimensions . . . C and D flanges or special flanges as required.

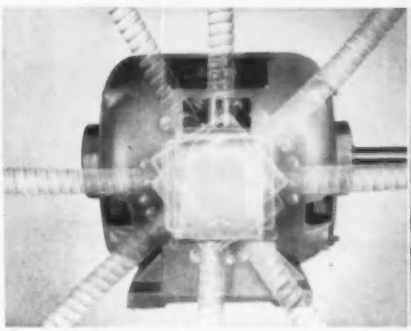
Produced by one of America's great industrial concerns, these motors are backed by a national network of 270 strategically located factory service stations. There's one near you—ready to provide 24-hour service on all parts and service orders.

For more information on A. O. Smith integral hp motors, write for new Bulletin No. EM156.

Through research A.O. Smith *. . . a better way*

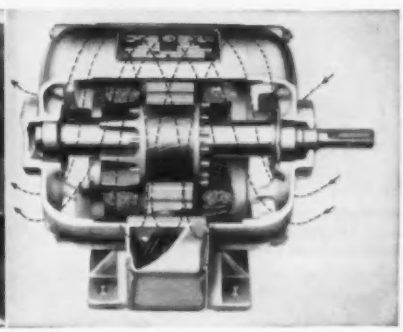
A.O.Smith
CORPORATION
ELECTRIC MOTOR DIVISION
TIPP CITY, OHIO
International Division: Milwaukee 1, Wisconsin

application-engineered to match your product requirements



FULL-ROTATING CONDUIT BOX
Can be set at any angle. Designed to save motor space and speed installation. Loosen only three screws to rotate conduit base.

DYNAMICALLY-BALANCED ROTOR
Assures continuous, vibrationless, trouble-free performance and maintains long bearing life. Indestructible laminations are high-quality silicon steel.



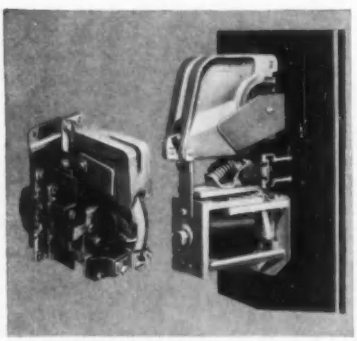
CONTROLLED THRU-VENTILATION
Cooling system designed for high-volume, low velocity air for maximum heat transfer. Temperature held to absolute minimum, assuring longer insulation life.

GENERAL ELECTRIC *Control*

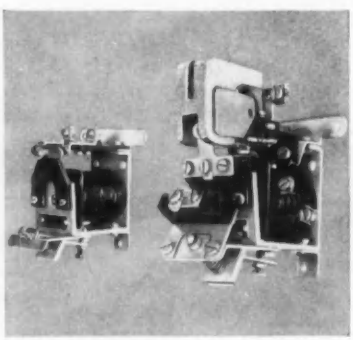
G-E control components cut assembly

GENERAL ELECTRIC CONTROL COMPONENTS ON LARGE PANELS—SUCH AS THIS STEEL MILL UNIT—HAVE RECORDS OF OUTSTANDING

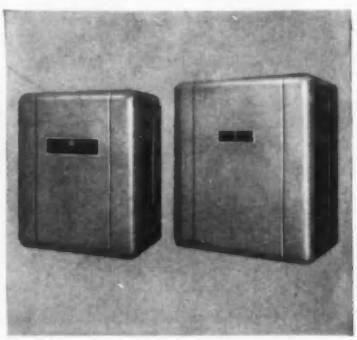
Wide Range of General Electric



LONG-LIFE CONTACTORS available in ratings from 1–2500 amperes, and can be specified mounted or unmounted.



ACCURATE RELAYS, ranging from general purpose control type to special relays, meet your own varying requirements.



DEPENDABLE DC STARTERS available in all popular NEMA sizes help give your motors complete protection.

G-E control components ranging from tiny resistors to large contactors, are available for all types of control boards.

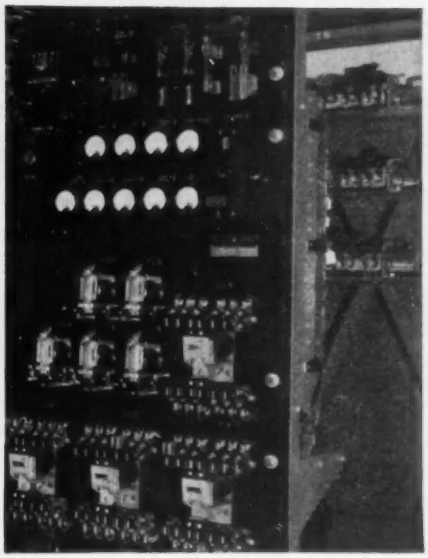
STARTERS

CONTACTORS

RELAYS

News for panel builders

time of large or small panels



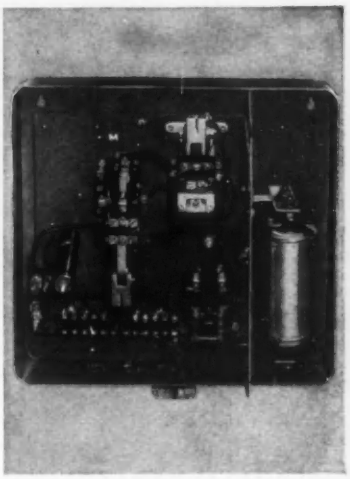
PERFORMANCE AND RELIABILITY.

Whether you build large steel mill panels or small panels for machine tools, General Electric's complete line of easy-to-install control components will help cut valuable assembly time.

G-E contactors, relays, resistors, starters, and rheostats have proven reliable in industry-wide applications. These control components are designed to give you top performance under all types of operating conditions.

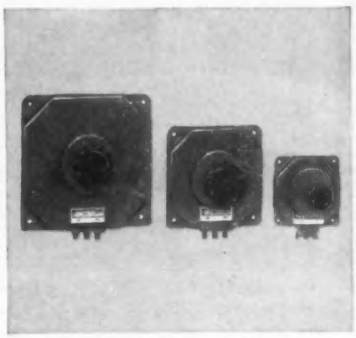
Fast delivery is another reason why you should specify G-E control components. Stocks of standard units are available from warehouses throughout the country. And, specially designed components receive particular attention at the factory.

If you have any problems concerning control components, experienced G-E engineers are available to help you select the correct components to help you meet your requirements. Contact them at your nearest G-E Apparatus Sales Office. General Electric Company, Schenectady 5, N. Y.

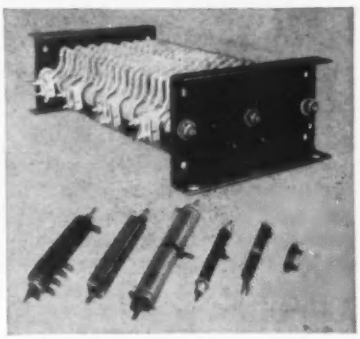


G.E.'s complete line of control components are used in large panels (left) or in small panels as shown above.

Control Components Available



RUGGED RHEOSTATS for field application are available in plate type construction for circuits up to 600 volts maximum.



RELIABLE RESISTORS in sizes ranging from 10 to 5000 watts are manufactured in single or multiple units to meet your particular need.

General Electric Company
Apparatus Sales Division
Section C784-2
Schenectady 5, N. Y.

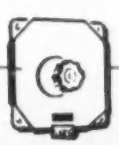
Check below for further product information.

☐ Starters ☐ Rheostats
☐ Contactors
☐ Relays ☐ Resistors

NAME.....

COMPANY.....

CITY..... STATE.....



RHEOSTATS

RESISTORS

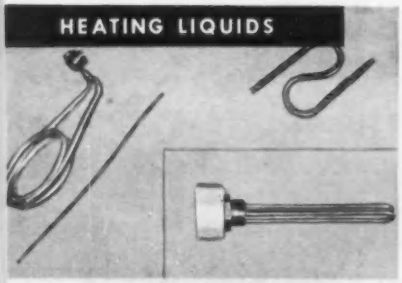
Progress Is Our Most Important Product

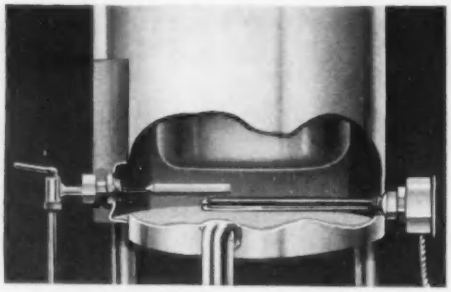
GENERAL ELECTRIC

DESIGNING HEAT INTO YOUR PRODUCT?

"1001" General Electric Heaters Give You Design Freedom Plus Easy Installation

HEATING LIQUIDS



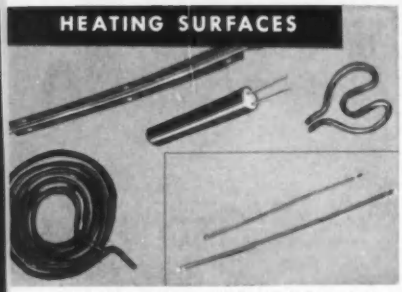


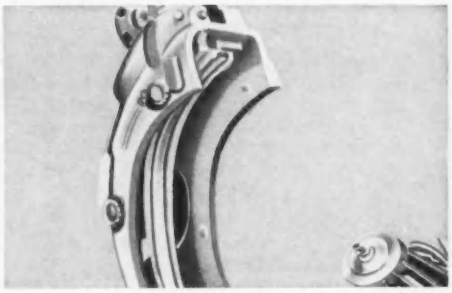
1 **GENERAL ELECTRIC** "screw-in" type heater is selected from wide variety of G-E immersion heaters by manufacturer of milk pasteurizers.

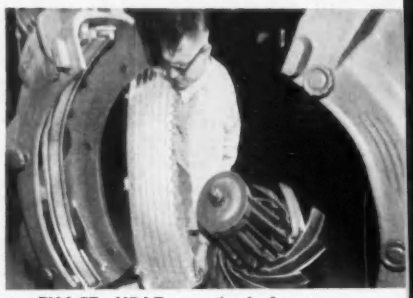
2 **EASILY INSTALLED** General Electric heater is inserted directly into side of pasteurizer. Immersion heaters provide maximum contact with water in jacket, minimizing heat loss.

3 **DEPENDABLE SERVICE** is assured by sealed terminals, high-grade resistance wire used in G-E immersion heaters. Milk spoilage is reduced.

HEATING SURFACES





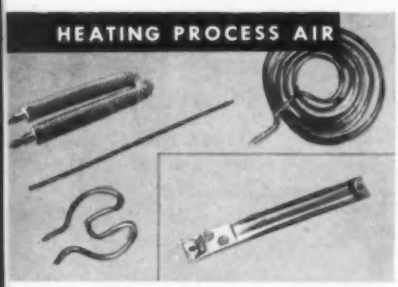


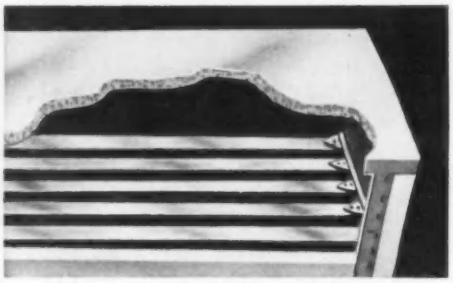
1 **FLEXIBLE BUT RUGGED** G-E tubular heaters are chosen by tire-retreader manufacturer after test. Other make heaters broke when formed.

2 **GENERAL ELECTRIC** tubular heaters bend easily to the curved shape of tire retreader. Heaters are inserted into grooves in heating plate to gain maximum heat transfer.

3 **EXACT HEAT** required for top-quality retreading of huge truck tires is achieved with high-efficiency General Electric heaters.

HEATING PROCESS AIR





1 **MANUFACTURER PREFERS** G-E "clamp-on" strip heaters for his high-temperature ovens. Versatile G-E tubular heaters could also be used.

2 **G-E STRIP HEATERS** are clamped to bottom of oven for maximum air movement. If a high degree of temperature uniformity is required heaters are clamped to top, bottom, and sides.

3 **FLEXIBLE PATTERN** and easy installation of G-E strip heaters reduces manufacturing costs—increases efficiency, improves saleability of ovens.

FREE

60-page Catalog of General Electric heaters and heating devices—describes full line. Also provides helpful application data. GEC-1005G.

Section E723-5, General Electric Company, Schenectady 5, N. Y.

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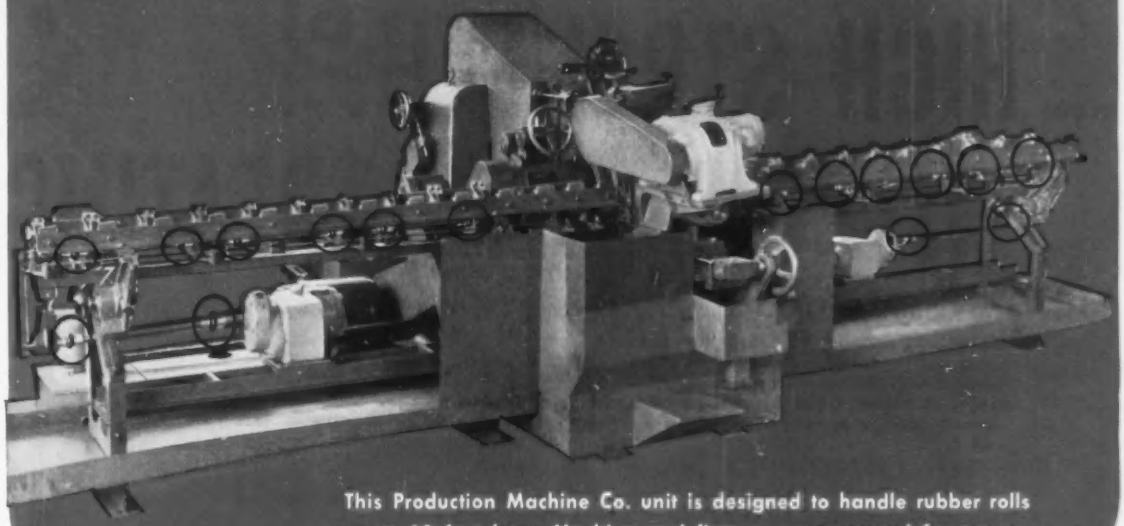
Company .....

Street .....

City ..... State .....

GENERAL ELECTRIC

there are 16 Apex Universal Joints on this polishing machine—all of them completely protected against damaging abrasive particles



This Production Machine Co. unit is designed to handle rubber rolls up to 10 feet long. Machine and fixtures are arranged for power-driven adjustment to accommodate roll diameters from 2" to 10".

A polishing machine creates an abrasive-laden atmosphere every time it operates. Minute particles wear away from the abrasive belts . . . other particles are polished from the workpiece. Preventing these particles from coming in contact with rotating parts of the machine presents a problem.

To help solve this problem, Production Machine Co. uses Apex covered universal joints. The sealed cover protects the joint from damaging abrasive action and also provides clean, sustained lubrication.

Apex *covered* universal joints operate efficiently under wet or dry, corrosive or abrasive conditions, or in extremes of temperatures. And Apex universal joints offer high overload capacity, lower deflection rate, superior fatigue resistance and a high strength-weight ratio per size.

To learn how Apex industrial universal joints may help make yours a better product, write, on your company letterhead please, for Bulletin 72 and the helpful Universal Joint Data Sheets.

APEX

industrial universal joints—3/8" to 4" diameters

THE APEX MACHINE & TOOL COMPANY
1039 S. Patterson Blvd. • Dayton 2, Ohio

another revolutionary development by La Salle

THE NEW fatigue-proof™ STEEL BAR

gives HIGH STRENGTH... WITHOUT HEAT TREATING

"FATIGUE-PROOF" steel bars offer high strength in-the-bar . . *without the expense and trouble of heat treating.* Tensile strength is in the 140,000 to 150,000 p.s.i. range . . hardness, which is related to this strength level, is approximately 30 Rockwell "C."

"FATIGUE-PROOF" has uniform strength across the bar . . and this uniformity is maintained from bar to bar . . lot to lot. This remarkable uniformity of strength makes "FATIGUE-PROOF" ideal for applications in the 140,000 to 150,000 p.s.i. range that formerly required heat treated carbon and alloy steels, either hot rolled or cold drawn.

yet it's EASY TO MACHINE

"FATIGUE-PROOF" machines at least 25% faster than annealed alloys . . 50% to 100% faster than heat treated alloys.

"FATIGUE-PROOF's" excellent machinability permits faster speeds, heavier feeds, better tool life . . your production rates will increase.

Distortion from machining is held to a minimum . . surface finish is greatly improved.

Our Sales Engineers will be happy to show you how you can cut costs and eliminate problems and provide samples for test purposes.

JUST PUBLISHED! Ask for your copy of this new 20-page booklet which gives additional information on the remarkable new "FATIGUE-PROOF."

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1430 150th STREET · HAMMOND, INDIANA

Manufacturers of America's Most Complete Line of Quality Cold-Finished Steel Bars

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Please send me your "FATIGUE-PROOF" Bulletin.

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Perspectives

IN DESIGN AND DEVELOPMENT

WHAT IS A NUCLEAR ENGINEER?

At the recent Nuclear Engineering and Science Congress, one of the technical sessions got around to discussing the educational requirements for a Nuclear Engineer. The subject was off to a rather rocky start when one of the speakers said that there was no such person as a nuclear engineer. He followed this up with the claim that any engineer now working in the nuclear field is a specialist of some sort, i.e., electronics, instrumentation, metallurgist, heat transfer, etc.

This did not mean, however, that the engineers now in college need not study the atom. All the panel members agreed that the responsibility rests with the universities for teaching the engineer to at least speak the language of the nuclear field. (A spokesman from Argonne National Laboratory said that a special knowledge of nuclear engineering was not necessary there; just good fundamentals. An engineer will learn fast on the job.) More important, the student should get a better grasp of the fundamentals, and not rely so much on the "handbook" knowledge and the restrictions it places upon an engineer in advancing himself. Inorganic chemistry, solid state physics, metallurgy, and thermodynamics are a few of the subjects to which more study should be given. There will be plenty of time for a student to specialize after he leaves the university.

EVERYBODY WANTS A PHYSICIST

The speakers who represented government laboratories and large private companies having a big stake in the nuclear field, are hard pressed for engineers for that line of work. When asked what kind of engineers they needed most, the answer usually was: "chemical and electronic"—but they quickly added: "But we will take any kind. We can train them." Places like Argonne National Laboratory, Oak Ridge, and Brookhaven have their own specialized training courses for engineers. When he was pressed for more particulars, one speaker said, "What we really need most, and it will be more evident as time goes on, are more physicists. A physicist takes over when the going gets rough, and, because of his training, has a much better approach to the difficult problems than does the engineer."

This brought immediate protests from the engineers in the audience, and the problem was resolved by saying that while the physicist is well schooled in the basic fundamentals necessary for such work, it is the engineer who gets the job done. It was agreed that a physicist could stand more courses in engineering at college, but the engineer needs more physics, at least two years of it, before he could become a reactor engineer.

NEED FOR A BROAD EDUCATION

Dr. John Huffman, of Phillips Petroleum Co., in stressing the need for a broader education in science and engineering, criticized the inertia of the universities towards specialization. "A number of the schools," he said, "set up courses on subjects like food technology, paints and varnishes, petrol-

(Continued on page 131)

what can you expect to pay for custom-molded plastic parts at CHICAGO MOLDED?

You'll pay no more—often much less—for plastic parts at Chicago Molded. Here's why . . .

CMPC engineers and designers know how to produce the part you need in the most economical way . . . consistent with quality. You *never* get suggestions that result in a poorer product! You *do* get advice based on sound practice . . . modern methods . . . and 37 years experience in molding every type of plastic material.

Chicago Molded's unbeatable facilities include the world's foremost mold engineering facilities, as well as every type and size of press – automatic, semi-automatic, double-ram, and thermoplastic injection. With these, CMPC produces anything from the smallest to the largest plastic parts – quickly, economically, and in any quantity.

CMPC "follow-up" service means continuing savings for you. Our engineers keep in touch with your operations, help eliminate costly, unnecessary frills . . . suggest better molding materials . . . even help develop whole new processes to make your product better, more saleable, lower priced. *Now you know why 60% of our business comes from firms we've served for 15 years or more!*

Chicago Molded publishes a data-packed magazine called *Plastics Progress* to keep you up-to-date on many of the latest developments in plastics. You can get a *free subscription* by filling out the coupon below! Better do it now.

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eum, sugar refining, and the like, just to get grants from the companies in those fields." M. A. Schultz, of Westinghouse Electric, supported this, and said, "Everyone agrees that a broad education is best, but industry wants a man with specialized training."

OTHERS IN FAVOR OF FUNDAMENTALS

The demands for students well schooled in fundamentals come from other places. J. R. Killian, Jr., President of the Massachusetts Institute of Technology, decries the "handbook" engineer. "There are many areas of technology that are now closed books to those engineers lacking creative powers, or to those whose training or analytical abilities never carried them beyond the superficial methods of handbook engineering."

Rear Admiral Hyman C. Rickover, Asst. Chief of the Bureau of Ships for Nuclear Propulsion, stated his views concisely at the recent Thomas A. Edison Foundation Institute meeting. He said: "A point that has been made clear to me in interviewing young graduates is that they know many facts —but they have not learned many principles. Principles are more important than facts, and far more difficult to master. But once a principle is learned, it becomes a part of one, and is never lost. The facts we learn are soon forgotten and their meaning changes with time. A trained man knows how to answer questions. An educated man knows what questions are worth asking.

"My concept of a good engineering course is one in which the student learns the principles of mathematics, of physics, of mechanics, of electricity, of metallurgy, and of chemistry. A thorough understanding of these leads easily to handling the facts associated with them. I do not believe that 'practical stuff' should be, or can be properly taught in a university. Nearly all college textbooks are several years behind current industrial practice. The employer who wants a 'practical' engineering graduate is simply hiring a man who knows how to make the same mistakes that have been made in his plant for the past ten to fifteen years."

The shortage of engineers that exists in almost every field also holds true for the atomic energy field. The extent of the shortage is pointed up by the action of the U. S. Atomic Energy Commission to hold a summer institute this year for specialized instruction for faculty members of engineering colleges. The institute will be co-sponsored by the National Science Foundation and the American Society for Engineering Education. All told, this year the AEC is setting aside $5-million to publicize nuclear engineering.

THE SCIENCES STUDIED LESS

To get at the problem at the high school level is difficult indeed. As Admiral Rickover states: "Under pressure from various groups, courses are being given whose educational value is questionable. Nearly half of our high schools offer little or no instruction in physics, chemistry, or in mathematics beyond introductory algebra. The percentage of high school pupils who today study physics is 4 per cent as compared to 23 per cent in 1900. For chemistry the figures are 10 per cent in 1900 and 7 per cent now. Algebra: 52 per cent in 1900 and 27 per cent now. Geometry: 27 per cent in 1900 and 13 per cent now."

Engineered by Tinnerman...

NEW SNAP-ON MOTOR CLIP REPLACES 4 PARTS

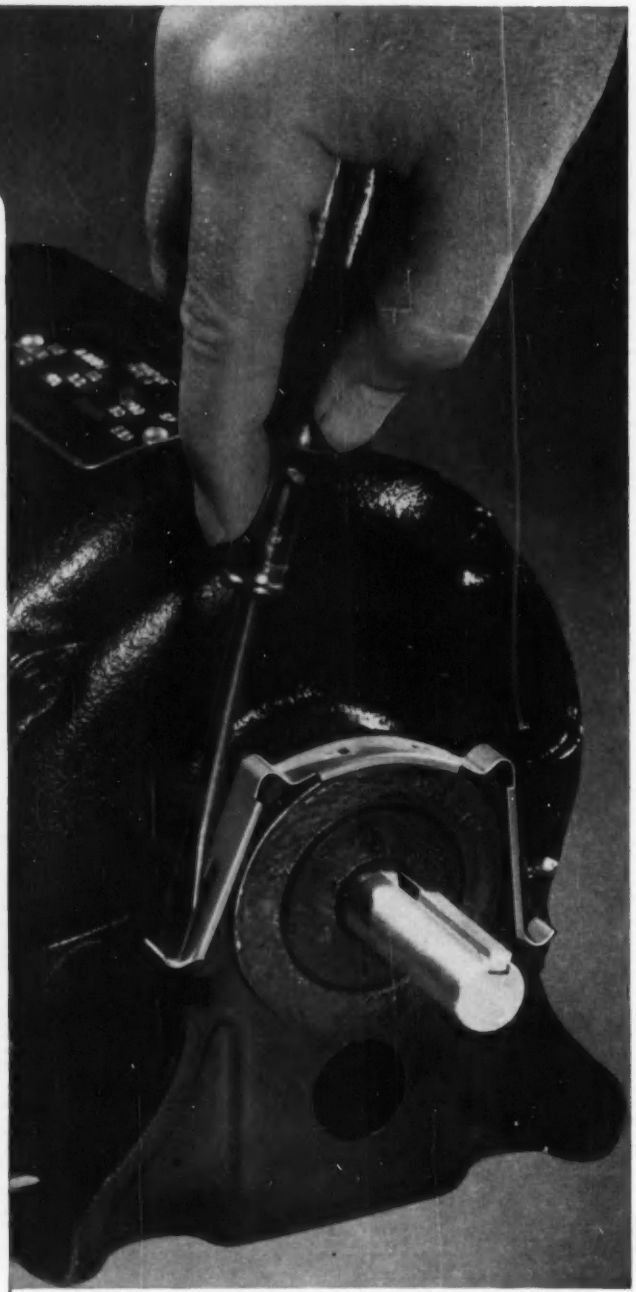
Cuts Assembly Time and Costs!

If you manufacture or use fractional horsepower motors, this new Tinnerman SPEED CLIP® can lower your parts and assembly costs by eliminating 4-piece screw clamps to hold motors in place.

Made of high-quality spring steel, this SPEED CLIP is quickly snapped into place over the resilient motor-mounting ring, using a simple hand tool. It forms a vibration-proof lock that won't shake free. Assembly time is reduced because of the one-piece construction . . . no loose parts to handle, nothing to tighten. Parts cost and assembly cost are reduced as much as 75%!

These SPEED CLIPS can be provided in sizes to fit any fractional-horsepower motor. They are designed to hold tight even under severest vibration and high starting-torque in any mounting position.

Ask your Tinnerman SPEED NUT sales engineer for more information and arrange for samples to test on your own assembly line.



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TINNERMAN Speed Nuts®
FASTEST THING IN FASTENINGS®

Innovation or Design Improvement

NEW MODELS AT FREQUENT INTERVALS keep the sales curve of many kinds of products at a high level. It seems to be necessary for salesmen to be able to talk about new features in automobiles, home appliances, trucks and other machinery. That is the reason for new models annually or at other intervals.

Fortunately for the design engineering profession, science and industry has been very generous in developing new materials, new types of mechanical parts, electrical devices and new hydraulic and pneumatic components. By keeping himself well informed of the availability of such new things, and getting familiar with their properties, characteristics and operation, the designer has relatively little difficulty in renovating his designs to make them modern both in appearance and performance. That is why it is essential, to both the company and the designer, that the latter shall take advantage of every opportunity to increase his knowledge of the latest offerings of science and industry with respect to materials and components.

Without a full knowledge of the materials and components available, there is the danger that the designer will find himself at a loss when a new model is required. He is then in a situation wherein he is unable to make material improvements in the design. Or perhaps he fears to adopt new components because he is not familiar enough with them. There may be little time to dig out the facts.

When the engineer must deliver the design of a new model but has failed to keep abreast of scientific and industrial progress in materials and components, there is only one thing he can do to cover up. That is, he can put a few innovations in the design and call it a "new and improved model," in spite of the fact that there is nothing basically new about it. But few customers are fooled!

Innovations are not to be condemned. Many of them have real merit. But a new model which has nothing more than innovations added to the old model will be in a weak sales position when competing with the new models that have basic design improvements as well as innovations.

George F. Zimmerschied

FACTS

about

NEW DEPARTURE

BALL BEARINGS

Another "NEW DEPARTURE"!
Pocket-size calculator calculated to cut costs!

Prices at your finger tips for over 100,000 different bearings! This "new departure" in the bearing industry lists basic engineering data, simplifies ball bearing selection, helps engineers figure design costs.

Instant information is available on New Departure's complete line of standard industrial bearings . . . and most important, the calculator cuts costs for buyers by spotlighting savings with low-cost, high-volume *standardized* ball bearings.

Ask your New Departure sales office about it . . . it's another New Departure "first" in ball bearings!

NEW DEPARTURE • DIVISION OF GENERAL MOTORS • BRISTOL, CONN.

Forming Titanium Sheet

Forming methods that work well for aluminum alloys often require substantial modification when applied to titanium alloy sheet because of differences in elongation, elastic limit, springback and buckling characteristics.

Specific design recommendations are offered for simple bending, drawn flanges, rubber forming, stretch forming and drop hammer forming.

Allowances for springback; how to prevent waviness in flanges and oil-can buckling; design of beaded panels, and limitations in forming large radii.

RICHARD E. PITTS
Supervisor of Tool Design and Research
Chance Vought Aircraft, Inc.

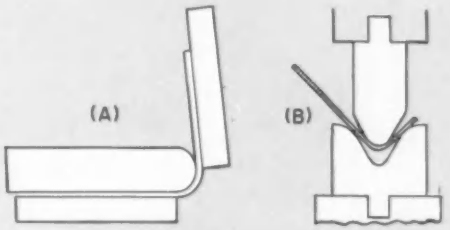

Fig. 1—Bending test fixture (A) with its wrapping action may take a smaller radius than can be obtained in brake forming (B) where friction against the die increases surface tensile stresses.

WITH THE HIGH PHYSICAL PROPERTIES now obtainable and a density two-thirds that of steel, titanium alloys give a strength-weight ratio superior to other light-weight materials over a wide range of elevated temperatures. However, many shapes obtainable in aluminum are not economically feasible with titanium at present.

Most formability problems in sheet metal involve insufficient elongation, excessive springback, excessive buckling, or a combination of these factors—frequently aggravated by an inadequate range between the elastic limit (yield) and the ultimate strength of the material where all forming is done. This narrow range requires close control of forming forces for production processes where the deformation is a direct function of the load applied. While aluminum alloy 75S-T6 can be readily formed in the annealed condition and heat treated to desired strength, this cannot be done with available high-strength titanium alloys.

To fabricate these titanium alloys, special bending methods are required with design limitations reflecting the limited forming range. Even in simple bending the ratio of radius to stock thickness requires more careful attention. Rubber forming has limitations arising from high springback. Rubber formed stretch flanges are more subject to rupture on the contour radius; wavy flanges and buckling are more critical problems.

For simple bending in a press brake using standard dies, the two important design considerations are minimum bend radius and minimum flange height. Minimum bend radius, as given by standard material acceptance tests, is often much smaller than is obtainable on production equipment under careful control. This is partly caused by use of leaf-type test fixtures, Fig. 1, in which the material is

customary to calculate the elongation e at the free edge of the flange by the following formula in which a is the angle of bevel, R is the contour radius, and W is the flange width:

$$e = \frac{1 - \cos a}{1 + R/W}$$

This formula assumes that all portions of the flange move upon radial lines drawn through the center of curvature, but this is true only when the segment angle is greater than 180 deg. When the segment angle is small, as shown in Fig. 6, the calculated stretch may be two or three times the actual elongation because of end relief along the flange.

Most common failure in rubber-formed flanges is rupture near the smallest contour radius at the free edge of the flange. A small nick in the free edge can cause rupture at relatively small values of apparent elongation. Titanium sheet has high notch sensitivity, particularly for high strength alloys. Values given here for formability limits are based on smooth polished edges; rough sheared edges may give flange heights of less than one-fourth the values for smooth edges.

Wavy Flanges

A second form of failure is a wavy flange which can occur in any material, when residual stresses after springback place the flange in compression. If the flange height is great enough there will not be enough support to prevent the edge from buckling in long waves. This effect is found only on large contour radii. Design limits are plotted in Fig. 7 in terms of h/t, the ratio of flange height to stock thickness, for two materials. Radius R is defined in Fig. 6. Although values are empirical, they follow the general shape of the secant formula for columns. The dotted portion of the curve, which is nearly flat, represents the design limit for splitting of the flange, while the curved portion to the right represents the limit due to buckling. The dotted portion can be reached only at very high pressures; the straight lines designated 7000 psi and 2000 psi represent the minimum flange which can be formed at those pressures. Parts below and to the right can be formed at lower pressures. These data are plotted in Fig. 8 in a form more convenient for design work.

Buckling Failures

Three other types of failure occur in rubber forming a stretch flange: buckling in the bend radius near the center of the stretch flange which occurs only in very small contour radii; shear buckling in the flange which occurs near the rupture limit so is seldom a design limitation; and an over-all bowing of the flat web when the part is released from the forming pressure. This last type of bowing resembles an "oil can" in appearance and can be removed by planishing; this type is particularly troublesome because it cannot be readily predicted. The tool cannot be shaped to avoid this effect except by trial and error, and even this is not entirely reliable because there will be an occasional piece which distorts differently.

This bowing tendency is increased by large flange heights, but may occur on any combination of flange height and contour radius. This distortion can be removed by stress relieving in fixture, a method that is also effective for small amounts of buckling if the fixture is adequate.

Springback in rubber-formed stretch flanges approaches that of straight flanges when the contour radius is large, but the springback ratio is not a direct function of the ratio of the flange width to the contour radius. For small segment angles springback is only slightly greater than that of the straight flange; large segment angles greatly increase the springback angle. For curved flanges the amount of springback is not linear with respect to the bend angle as it is for straight flanges. Consequently, springback tables for straight flanges can be used only as a preliminary guide to reduce the number of trials when developing form blocks on a cut-and-try basis.

Shrink Flanges

Rubber-formed shrink flanges formed at usual pressures of about 2000 psi are feasible only over a very limited range: a flange narrow enough to fall within the limits of adequate shrinkage usually does not have enough width to provide leverage for the rubber. Consequently, shrink flanges formed at conventional pressures must have notches at intervals of 2 in. or less.

Increased pressures, 5000 psi and higher, have only a small effect in forming shrink flanges but do make possible several forming aids which greatly increase the feasible amount of shrinkage. A sandwich construction with the titanium sheet enclosed by two thicker sheets of mild steel increases the effective thickness and thereby decreases the tendency to buckle. Since the added sheets are of low strength only little more force is required.

Beaded Panels

The production of beaded panels in titanium alloys is not feasible at ordinary pressures at room temperature because of excessive bowing and twisting. Elevated temperatures help, but some buckling still occurs and definition of the bead is poor. A combination of high temperature (in excess of 800 F), and a pressure of 6000 psi will produce beaded shapes comparable to annealed aluminum alloy at 2000 psi at room temperature.

The lowest ratio of width to depth (see Fig. 9) for 75S-O aluminum at room temperature is 5½ to 1. This can be equalled in titanium sheet by high pressure forming at room temperature; addition of high temperature will bring this ratio down to 4½ to 1. These ratios refer to multiple bends in which the material for the bead must be stretched from the flat sheet, with little or no drawing action.

If a single bead is required in a narrow sheet the material is pulled from the edge in the same manner as in a deep draw, and the only limit on depth is the number of stages of tooling. Ordinarily not more than two stages are justifiable, which limits the depth to about one-half the width.

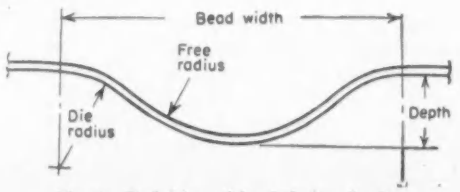

Fig. 9—Definition of bead design details.

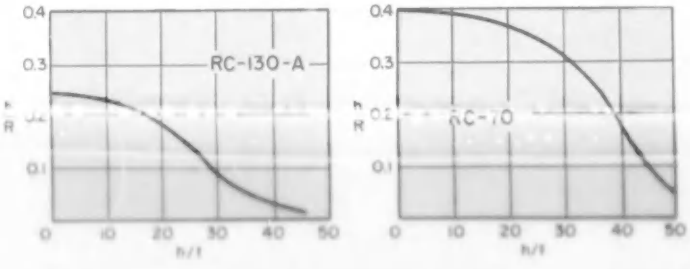

Fig. 10—Forming limits for flanges produced by contour stretch forming in two titanium alloys, in terms of flange height *h*, contour radius *R* and stock thickness *t*. Scales for ordinates are same as used in Fig. 7 for rubber-formed flanges.

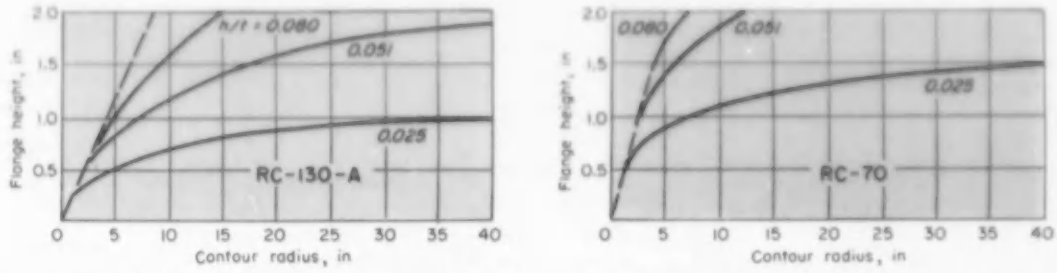

Fig. 11—Forming limits for contour stretch forming given in Fig. 10 plotted in terms of flange height and contour radius.

Forming Large Radii

Accurate contours for large radius parts can be produced only by some form of stretching, either on a sheet stretch press, or with trapped beads in a drop hammer, or by the Anderson "Form-by-Draw" process. Forming titanium alloy sheet on a stretch press requires a temperature between 800 and 1000 F. Above 1000 F parts have so little strength that the dies must be cooled before the part can be removed.

While elongations of 18 per cent have been obtained at the center of the sheet, these parts showed 7 per cent stretching at the edges to minimize springback. The effective elongation was about 10 per cent difference in length between the center of the sheet and the outside edge. This limit applies primarily to dome-shaped parts, in which the curvature is convex in both directions. In saddle-shaped parts, in which the curvature along one axis is convex and along the other axis is concave, buckling requires a more conservative allowance—about 6 per cent is the most that should be attempted.

Compound curves can be produced by the Anderson "Form-by-Draw" process at room temperature. This process is performed on a machine adjustable to forming an infinite number of shapes. This method has widest use for long shallow curves such as are found in the major portion of a fuselage; it cannot form sharp radius curves in both axes, such as nose skins. When the curvature along the width of the sheet is very slight the radius along the length may be as small as 2 in.; the radius across the width of the sheet must be at least 1½ times the width of the sheet.

Contour Stretch Forming

In this widely used method for titanium shapes, angles can be readily formed to shapes which are comparable to shrink flanges in rubber forming. Rubber-formed shrink flanges, which are very difficult to produce, can be readily stretch formed. Latitude in formability depends on the type of work; shapes supported by the forming die without any loose pieces have more latitude. The use of a "snake" or flexible piece to support the part and prevent local buckling limits formability.

Column buckling is one form of failure in stretch forming just as it is in rubber forming. Forming limits, Figs. 10 and 11, are plotted in the same manner as in Figs. 7 and 8. Because the range of plastic flow is so narrow, control of forming by strain is more desirable than control by stress.

Elevated temperatures give little or no advantage. Temperatures high enough to increase the elongation also increase the tendency to necking; once started, necking causes rupture before the press can be stopped.

Drop Hammer Forming

Because of the wide variety of shapes produced by this method, it is difficult to define design limitations. For beaded panels deeper beads can be produced by drop hammer dies than on a rubber press because the smooth metal surface of the die has less friction and permits more drawing action than does the usual rubber forming die. Shallow shapes usually made on a stretch press can readily be produced on the drop hammer by holding the periphery of the part in trapped beads. Deep drawn shapes are normally produced by mechanical draw dies in a hydraulic press, but for limited production it is sometimes more economical to produce these shapes in drop hammer dies with stage forming.

Parts most suited for drop hammer forming are: complex shapes usually requiring both shrinkage and stretching of the material; and limited production runs, for which more conventional tooling would be expensive. Drop hammer forming at room temperature is impractical; the sudden impact causes failure by rupture at elongation values of less than half that produced under slow pressure. Consequently, drop hammer forming is invariably done at elevated temperatures.

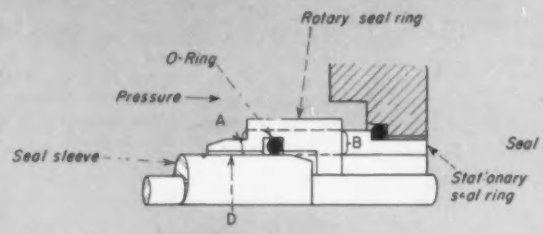

Fig. 1

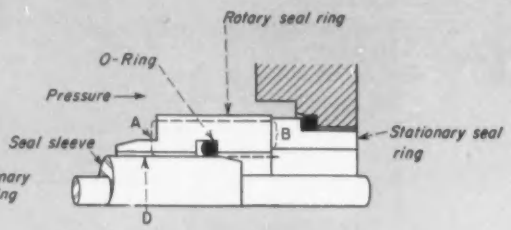

Fig. 2

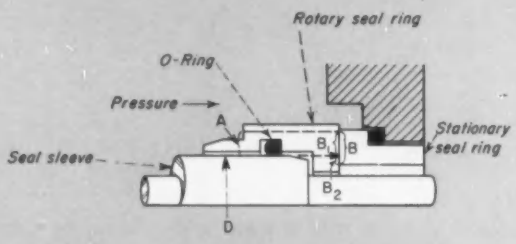

Fig. 3

Fig. 1—Unit face load on the contact area *B* between the rotary and stationary seal rings is equal to the contained pressure while in the seal design of Fig. 2 face area *B* is smaller than the hydraulic piston area *A* resulting in a unit face pressure greater than the contained pressure by the ratio *A*/*B*. The properly designed seal in Fig. 3 provides for a unit face load which is a constant percentage of the contained pressure, in this example approximately 70 per cent.

Rotating Seals for High Pressure

Effect of hydraulic balance, structural design, packing and seal face materials on selection of rotating mechanical seals for severe operating conditions.

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MECHANICAL SEALS OFFER SOLUTIONS to many extreme operating conditions where conventional packings may prove unsatisfactory. Design of mechanical seals involves four inter-related factors: hydraulic balance, structural design, packing material and design, and seal face material.

Hydraulic Balance

The balanced seal has the lowest face contact pressure consistent with leak-proof performance. Initial face load is provided by the seal spring or springs. This initial load should be just sufficient to prevent leakage at zero gage pressure. As fluid pressure increases it will act on radially disposed areas so as to increase the face pressure in proportion to the fluid pressure. Close control of these radially disposed areas will allow the seal face contact pressure to be maintained at a value lower than the pressure sealed.

In practice, minimum seal face pressure that will prevent leakage is maintained between faces. Under high pressure service and at normal shaft speeds, which may be several thousand rpm or greater the basic problems are to maintain sealing faces flat within optical limits, provide a contact pressure which will prevent leakage but not squeeze out lubricating film, and produce a minimum of frictional heat. Frictional heat must be dissipated in some manner or high temperatures will destroy lubricating film and injure sealing faces and packing materials.

In Fig. 1, all the contact face area B is disposed outside of the effective sealing diameter D and the hydraulic piston area A of the seal ring is equal to the contact face area B. Fig. 1, therefore, represents a condition in which the average face load will be 100 per cent of the hydraulic pressure sealed. If the seal were used at 1000 psi pressure, the unit face loading on the sealing faces would also be 1000 psi.

In Fig. 2, all of the contact face area B is disposed above the effective sealing diameter D and the hydraulic piston area of the seal ring A is greater than 100 per cent in accordance with the ratio of area A to area B. The unit contact face loading will actually be higher by an equivalent percentage than the hydraulic pressure sealed. This condition prevails in most unbalanced seals and is highly undesirable for high pressure service.

The relationship of most balanced seals is shown in Fig. 3. Here, part of the contact face area B, designated as B_1, is disposed outside of the effective sealing diameter D. Area B_1 is, therefore, equal to the hydraulic piston area A. Since the rest of the seal face area B_2 is located inside the effective sealing diameter D, the total seal face area B will equal the sum of B_1 plus B_2 and the unit face loading will be less than the pressure sealed, in accordance with the ratio of the two areas or $B_1/(B_1 + B_2) = A/B$. This value, expressed as a percentage, indicates the balance of the seal. In this manner, a seal may be balanced with anywhere from zero to 100 per cent unit face loading.

The theoretical possibilities which may occur within the lubricating film between two sealing faces are shown in Fig. 4. Line A represents a uniform pressure drop across the sealing face varying from sealed pressure on the inside edge to atmospheric pressure at the outside edge of the sealing face. Resultant average pressure of the lubricating film in this case is 50 per cent of the hydraulic pressure sealed and the seal overbalance must be somewhat greater than 50 per cent to maintain the seal tightly closed for operation without leakage.

Many investigators have attempted to apply conventional flow formulas for narrow channels to the pressure drop calculation and theoretical analysis seems to indicate some variation from a uniform pressure drop across the sealing face. The flow formula, however, is based on assumptions which cannot be measured or will frequently change in operation such as film thickness, or film shear strength. Because of these and similar uncertain variables, the application of the flow formula to seal design has not yet been reliably accomplished. The application of the conventional flow formula, however, does prove the importance of many of the design features such as face flatness and stress.

For normal usage under intermediate pressure conditions, most seal manufacturers have experimentally selected a balance of approximately 70 per cent which, with a face width of approximately $\frac{1}{8}$ in., will provide effective sealing. It has been observed in actual practice, however, that the minimum permissible balance conditions will vary with the medium sealed. This is attributed to variations in the pressure drop across the sealing faces and the viscosity of the sealed medium is observed to be a general guide to the face pressure distribution. With very low viscosity media such as propanes, butanes, ammonia, and the like, it has been observed experimentally that a face balance of approximately 70 per cent must be maintained to insure that the faces will stay closed. Pressure distribution across the sealing faces must follow a pattern similar to line B, Fig. 4, where the average pressure is approximately 70 per cent.

With a slightly more viscous material (water) again experimentally, it has been observed that a balance of 58 to 60 per cent is sufficient to resist any tendency for the faces to open. This is a pressure distribution similar to line C, Fig. 4, with an average unit face pressure of approximately 60 per cent of maximum.

Heavy viscous materials such as heavy lubricating oils, operate satisfactorily with balances of only 30 to 40 per cent, indicating a pressure distribution similar to line D, Fig. 4, and an average unit face pressure of approximately 40 per cent.

An optimum seal could be designed for each media sealed; however, in the interests of standardization, it has been found economical to design for the low viscosity materials. Satisfactory operation is then obtained with other media because molecular cohesiveness and the resultant lubricating properties are progressively better as the viscosity increases.

Note that the above balance values have been developed from experimental results obtained with approximately $\frac{1}{8}$ in. wide faces. Where sealing faces are either wider or narrower, hydraulic balance percentages vary inversely with the length of the leakage path. Determinations of optimum combinations of face width and hydraulic balance is dependent on experience and test data.

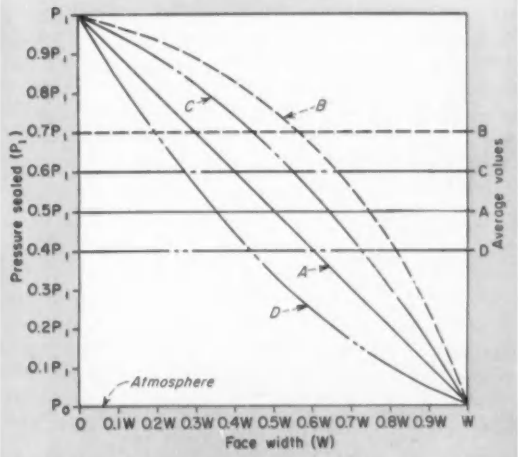


Fig. 4—Pressure varies along the face width dependent upon the viscosity of the lubricating fluid. High viscosity fluids (*D*) may have average pressures as low as 40 per cent of the pressure sealed. Low viscosity fluids (*B*) may have average values of 70 per cent of the pressure sealed. Unit face pressure must be equal to or slightly higher than these average values in order to maintain the seal.

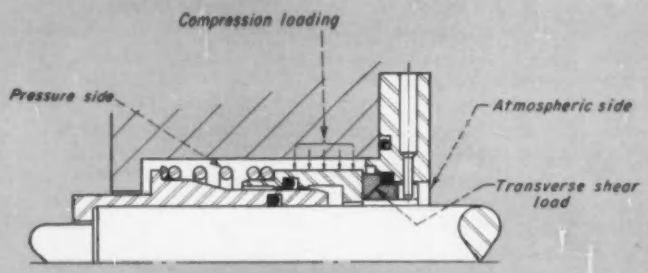


Fig. 5

Fig. 5—Rotating seal ring is here compression loaded by the contained pressure. Face flatness is least liable to distort under this loading. The stationary seal ring must be sufficiently strong to withstand the combined shear and compression imposed.

Fig. 6—In this design the moving seal ring is placed in tension by the high pressure fluid on its internal diameter. High pressures tend to distort the moving seal ring out of flatness.

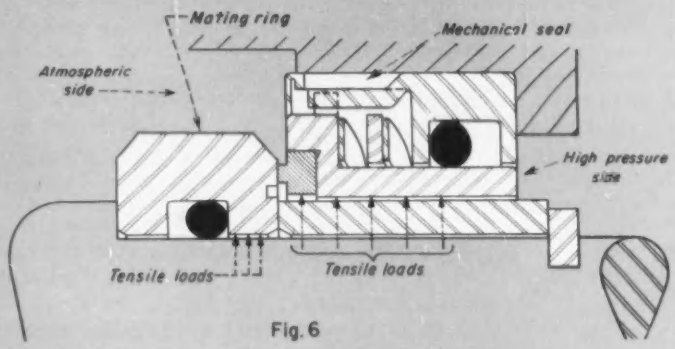


Fig. 6

Structural Design

The housing of the seal or adjacent assembly must be reviewed to determine the structures that are suitable for maximum pressure conditions. Compressive or tensile loads, dependent upon the seal design, will affect the face flatness and ability of the sealing ring to maintain an adequate seal. Compressive loads have much less influence than tensile loads on the face flatness. It is, therefore, desirable to maintain the critical components in compression rather than tension under all phases of operation. Fig. 5 illustrates a typical seal design which maintains the rotating seal ring in compression. The stationary sealing members are in a combination of compression and shear, and the stationary sealing ring must be rigidly backed and provided with an adequate cross section to reduce the shear loads to a low value. Fig. 6 illustrates an arrangement where the rotating seal ring supports the hydraulic load in tension, which would be undesirable for high pressure service.

For reliable face sealing, the maximum compressive load on bronze materials should be held to approximately 5000 pounds per square inch and on ferrous seal rings to approximately 8000 pounds per square inch.

Selection of Packing Materials

If temperatures do not exceed 300 F various synthetic elastomers are available. Most high pressure seals using elastomers have O-ring type construction for packing components. Because of its simplicity and reliability the O-ring seal will operate effectively at pressures up to 2000 and 3000 psi. However, strict attention must be paid to the groove clearances to prevent extrusion and pinching of the O-ring. Backup washers must be employed at pressures above 500 to 700 psi depending on clearances. For ambient temperatures above 300 F and up to 450 F, teflon packing components in the form of U-rings or wedges are frequently employed. When operated at elevated temperature, teflon softens and also exhibits a tendency to extrude into clearance spaces. For this reason, it is not normally employed at pressures over approximately 400 psi unless the temperature is well below the maximum recommended value of 450 F.

Seal Face Materials

Selection of seal face materials for the running faces may affect both the structural design and the hydraulic balancing factors. Various types of carbons in combination with a metallic face are used with fluids having poor lubricating properties, while both carbon-to-metal and metal-to-metal combinations are used for fluids having good lubrication qualities.

Metal face components in high pressure seals may include tool steels, nitralloys, stellite (or equivalent) facings, or solid stellite, tungsten carbides in various grades either solid or plated, and even softer materials such as bronze, cast iron, meehanite and ni-resist. Carbon is normally operated against one of the harder materials such as stellite or tungsten carbide. Where corrosion is a factor, these faces are suitable for handling a wide variety of chemicals. Hardened steels, nitralloys, cast iron and

similar materials will usually be restricted to noncorrosive fluid applications.

Stellite and carbon combinations are in common use at pressures up to 1000 psi with hydrocarbons and similar fluids. Above this pressure tungsten carbide of various types may be used and where abrasive problems exist, the use of tungsten carbide will be extended to much lower pressures. Tool steels and nitralloys, or materials of this type, are being successfully adapted to seals operating at pressures up to 2000 to 3000 psi on fluids with good lubricating characteristics like the hydrocarbons or similar fluids.

Solid carbides are normally superior in operating characteristics to plated or welded construction, but solid carbide does not lend itself to intricate or complicated designs for components. Solid carbide parts should be relatively simple and uniform in cross section to reduce the cost of manufacture.

Operating Limitations

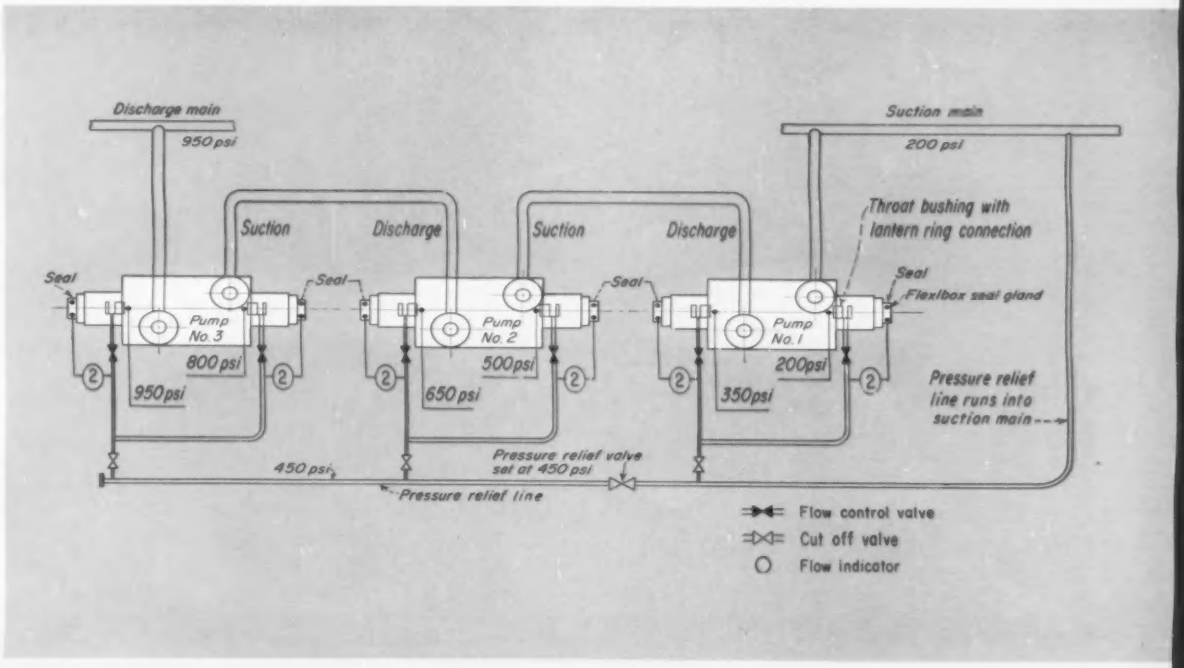
Control of operating conditions is usually exercised by auxiliary features applied to the process or device upon which the seal is required. In pumps whose temperatures are beyond the desirable limits, recirculation of pump discharge through coolers may be required to maintain seal temperatures within safe operating limits. If a continuous flow process is involved, the medium handled may be available at a lower temperature at some other point in the process where it can be bled back to the seal cavity to maintain a temperature control without the necessity for added cooling equipment. The same solution applies for products which may be too cold for normal packing components.

Where vessel pressures are beyond the limits of a mechanical seal, it may be necessary to provide throttle bushings, restrictions or labyrinths, which allow the seal cavity to be bled off to a lower pressure in the system with a vent line recirculating the fluid which leaks off through the labyrinths or restrictions.

An arrangement using controlled circulation and pressure break-down is shown in Fig. 7, illustrating a typical pipeline installation involving three multi-stage pumps with mechanical seals on each of the two boxes per pump. At the high pressure end, all the stuffing boxes are held at a common maximum pressure of 450 psig, while at the lower pressure end of the circuit, somewhat lower pressures are maintained on each individual stuffing box or seal cavity. When connections of this type are possible, the system is automatically in operation when the pumps are placed into service and no external pumps or other pressure equipment is required.

In new equipment design involving high pressure sealing problems, it is imperative that the seal designer be contacted before equipment design is finalized. Where design requirements are rigid, space allotted to the seal may be of paramount importance and it may be necessary to make provisions for modifying the operating conditions within the sealing cavity. With the close cooperation between seal designer and manufacturer and the seal user, the trend toward mechanical seals for severe and extreme applications will show continued advancement.

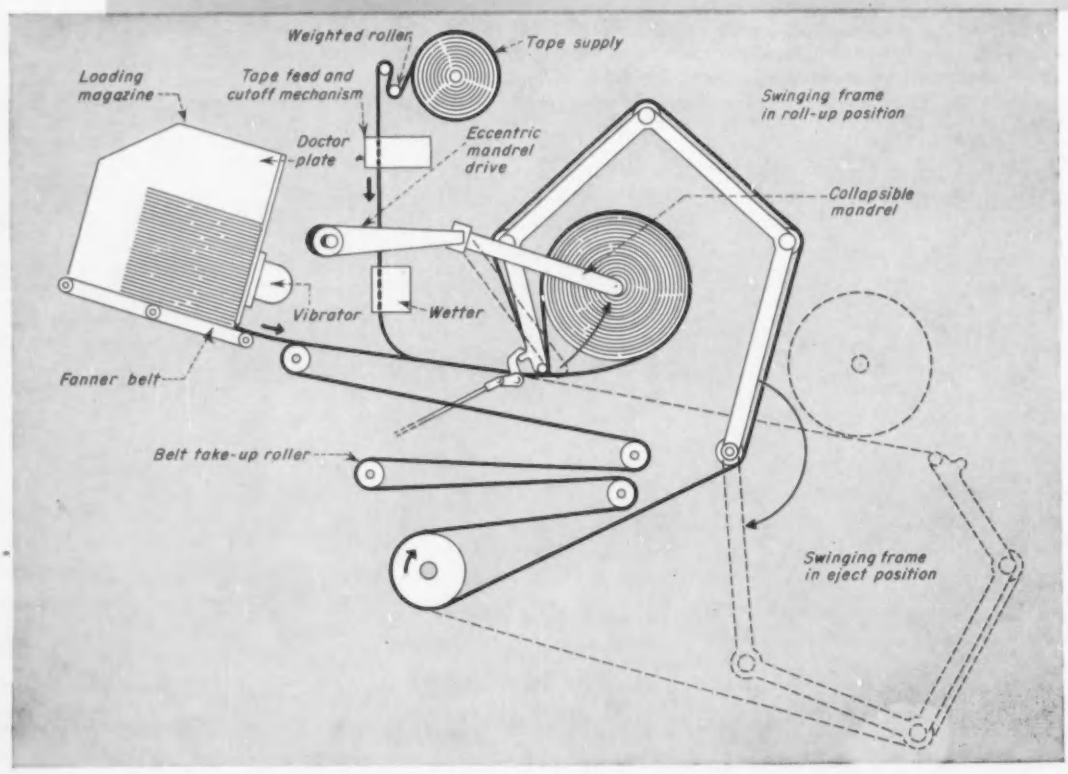
Fig. 7—Pressure drop across high pressure seals may be lowered to values below the maximum pressure in the circuit by controlled flow and pressure distribution. In this manner demands on individual seals are reduced and seal design is less critical.



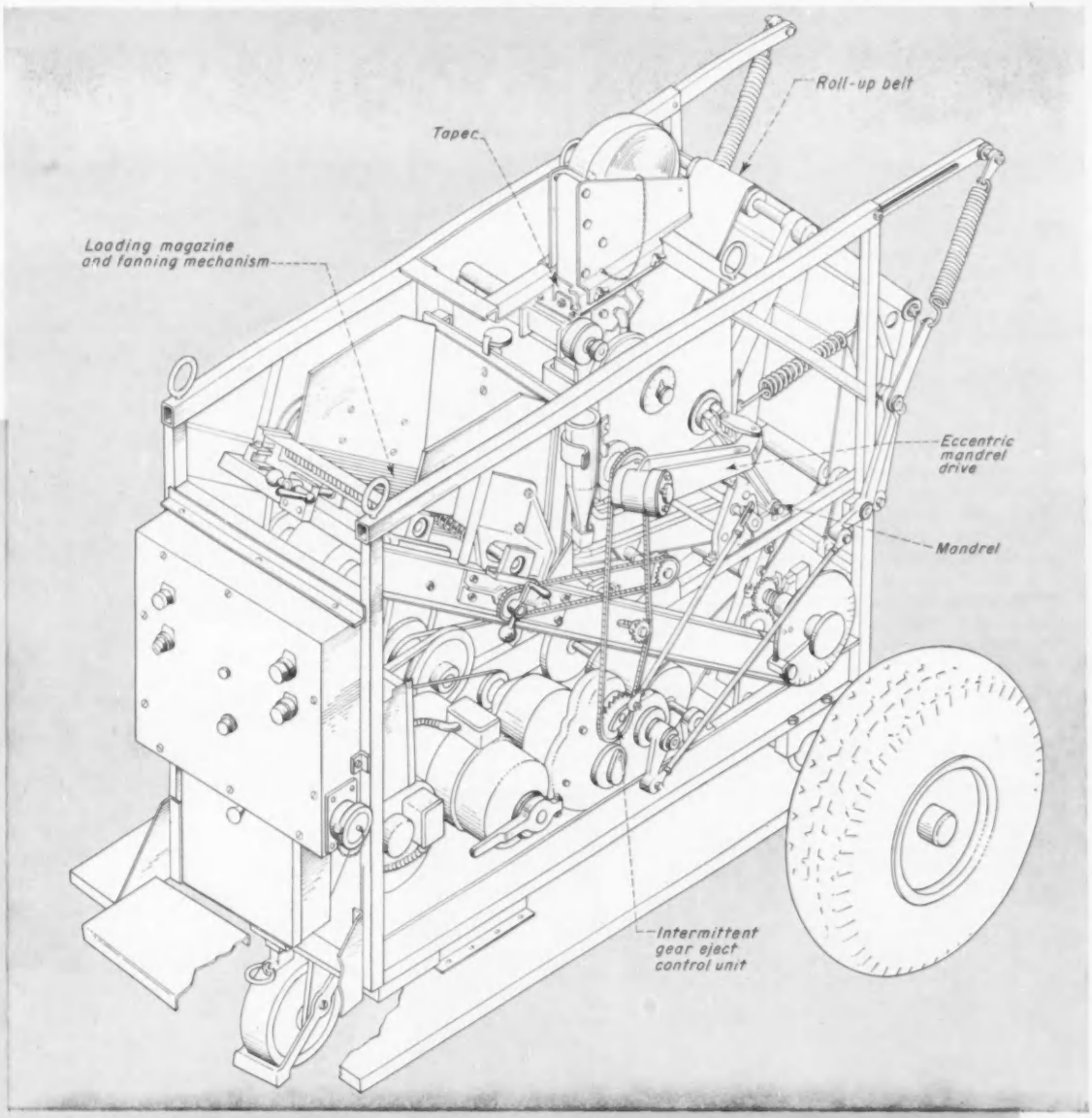
Machine Packs 4,000,000 Leaflets Per Day

Leaflets feed at 400 ft per min through an automatic packaging machine designed for the air force by the Buffalo Advanced Development Group of American Machine & Foundry Company. This high-speed operation is made possible by a combination of mechanisms and electric controls. The machine has four elements: fanner, roll-up mechanism, taper, and ejection mechanism.

THE CYCLE BEGINS when the fanner and roll-up belts feed leaflets to the roll-up mechanism. A spring loaded take-up roller actuates a limit switch when the roll reaches the set diameter. This stops the fanning motor and energizes the tape feed after a time delay. Tape is cut, end-wetted, and wrapped around the roll by continued action of the roll-up belt. Another time delay allows the tape to wrap the roll and be sealed before the belt drive stops and the ejection drive starts. The ejection drive is a single revolution motion. The first half unfolds the roll-up mechanism to discharge the roll while the second half returns it to the initial position. This return motion starts the fanner for the next cycle.



IN NEW PRODUCTS



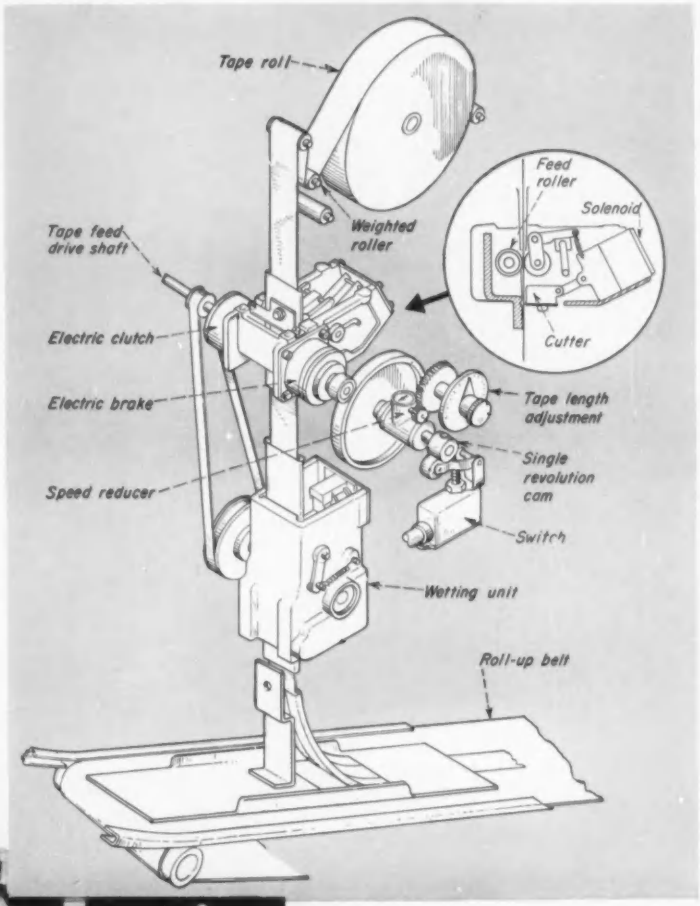
THE FANNER DESIGN coordinates relationships of such factors as opening between vibrating doctor plate and fanning belt, shape of lower edge of doctor plate, angle of the loading magazine, speed of the fanning belt and both frequency and amplitude of the vibration used to energize the doctor plate. Some of these relationships are critical and require considerable experimentation to determine the optimum arrangement.

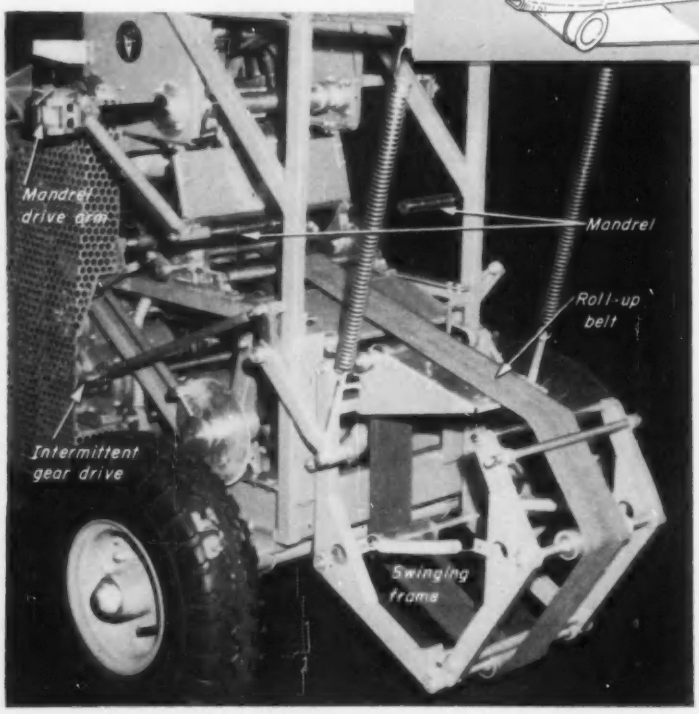
(continued on next page)

A COLLAPSIBLE MANDREL looped by the roll-up belt starts the stream of leaflets rotating into a roll. The spring loaded take-up roller feeds additional belt-length to the roll-up system as the package diameter increases. Roller position measures package circumference and actuates a cam-operated electrical switch when the desired roll diameter is obtained. Diameter is adjusted by varying cam position. Careful control of belt finish and slippage keeps static electricity at a low level, permitting the charge to be carried off by the paper.

Machine Packs 4,000,000 Leaflets Per Day (continued)

THE PRESET LENGTH OF TAPE is cut, wetted on one end and fed into the roll-up mechanism intermittently at 400 ft per min. A single revolution cam actuates an electrical switch to energize the solenoid-operated cutter and the wetter transfer roller. The cam is driven by the tape feed roller shaft through an infinitely-variable-ratio speed reducer which is set by the tape-length adjustment. Tape feed is controlled by an electric clutch and brake combination. A weighted roller absorbs the intermittent acceleration of the tape at the supply roll. Water for wetting is heated to make the tape adhere properly. Although the temperature is not high, a vapor shield was found necessary to prevent the wetting of tape above the transfer roller.

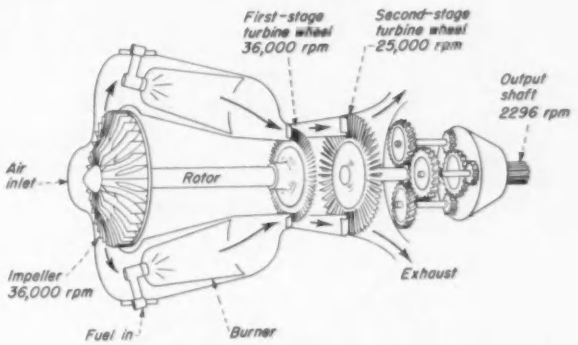




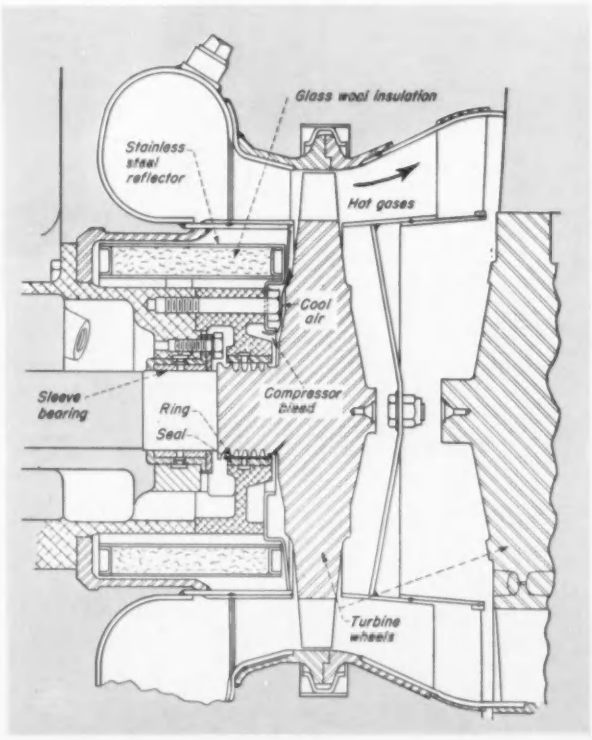
AN INTERMITTENT GEAR DRIVE opens the swinging frame, ejects the roll and returns the frame to the roll-up position. Two eccentric mandrel drives convert the rotary motion of the eject control unit to harmonic reciprocating motion at the mandrel support shaft. This action withdraws the collapsible mandrel and its core on opposite sides of the machine, allowing the roll to be ejected. The core acts as a cam which expands the mandrel when pressed in and allows it to collapse when withdrawn.

Rotor Unbalance Adjusted By Floating Bearings

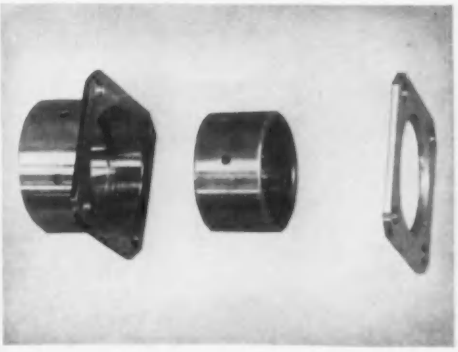
Conventional bearings were excessively loaded if the rotor in the Boeing Model 502 Gas Turbine became slightly unbalanced. The problem was solved by mounting the rotor on floating thrust and radial bearings which automatically adjust for unbalance up to one in.-oz.

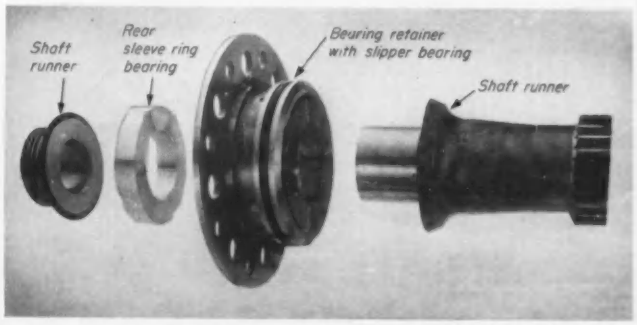


AT 36,000 RPM, one in.-oz of rotor unbalance created a 2200 lb load on the conventional bearings. Rotor assembly is now mounted on three floating bearings, one near center of shaft, one at each end.



SLEEVE BEARING SHOWN (and each of two bearings not shown) has double clearance, to permit rotor rotation to shift from center axis of shaft to true rotational axis, in event of unbalance. The bearing sleeve rotates at about half the rotor speed, is pressure lubricated. Frictional losses associated with plain bearings are effectively minimized by accurate lubricant control and use of low viscosity oil at high temperature. High temperature gases are kept from reaching the bearing by bleeding cool air from the turbine compressor, as shown.



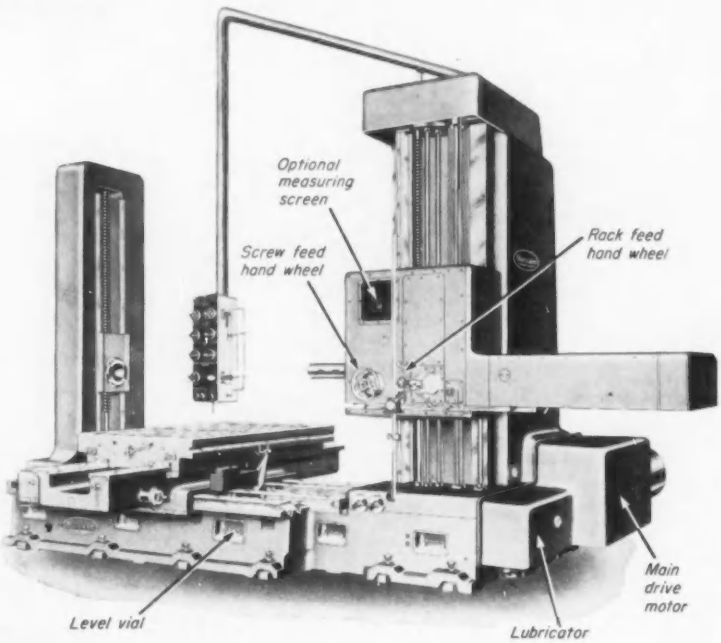


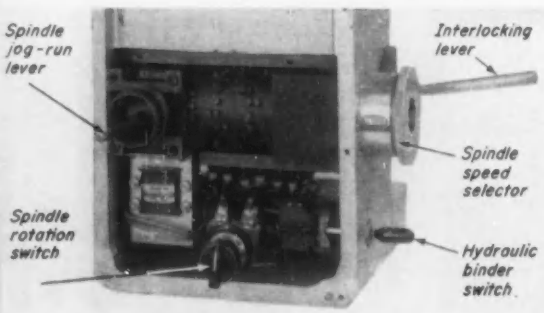
SLEEVE bearing (above) is made of aluminum alloy with no plating. Slipper-type thrust bearing (left) is of same material. The slipper bearing carries the main thrust load; the ring bearing takes the radial load. Thrust ball bearing previously used forced the rotor to turn on ball centers, subjecting the rotor to ball race run-out errors.

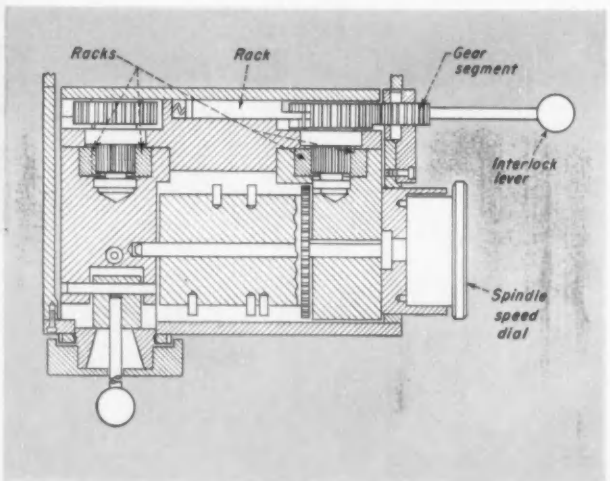
Boring Operation Improved Through Hydraulic Controls

All feed mechanism has been eliminated from the head in the Model 75 Horizontal Boring, Milling and Drilling Machine manufactured by the Bullard Co., Bridgeport, Conn., by mounting the drive and feed unit in the head post and bed, through use of electro-hydraulic controls. Hydraulic cylinders are directly coupled to the clutch shifting rods, eliminating linkage. The head is hydraulically counter-balanced, and bound by hydraulically-actuated toggle clamps. The pendant control can be positioned in three directions, including powered elevation.

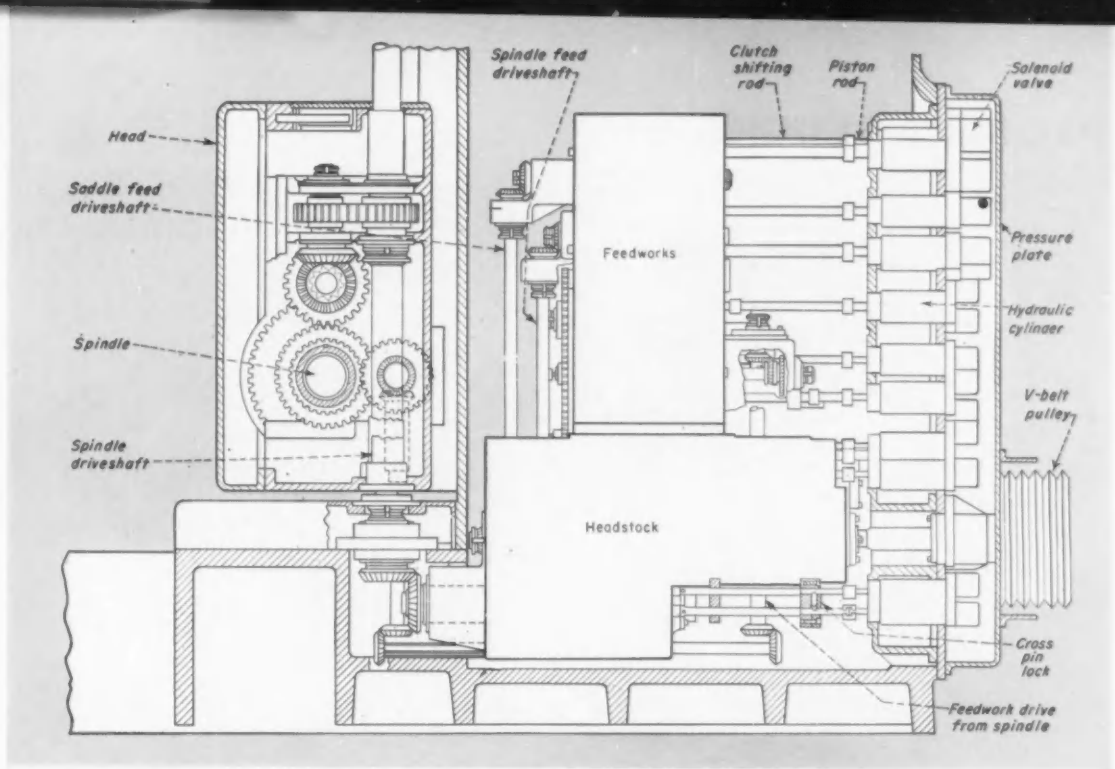
ALL CONTROL OPERATIONS can be performed from the pendant station; directional levers are used for both feed and traverse. Pendant is vertically powered by motor (mounted on top of head post) through worm gearing. Manually, the pendant can be swiveled through a 270-deg arc, and positioned toward and away from the head with the horizontal overhang riding on ball bushings. Note the optical measuring screen is placed to allow reading as operator works pendant controls. Level vials placed around bed provide check to help maintain work accuracy. Cast iron ways are chrome-hardened.





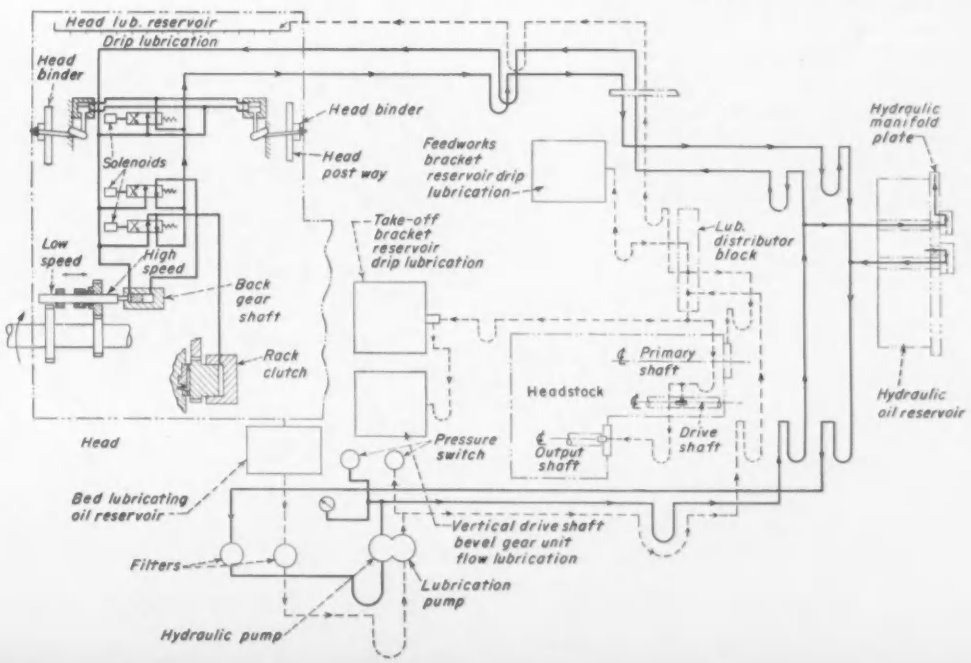


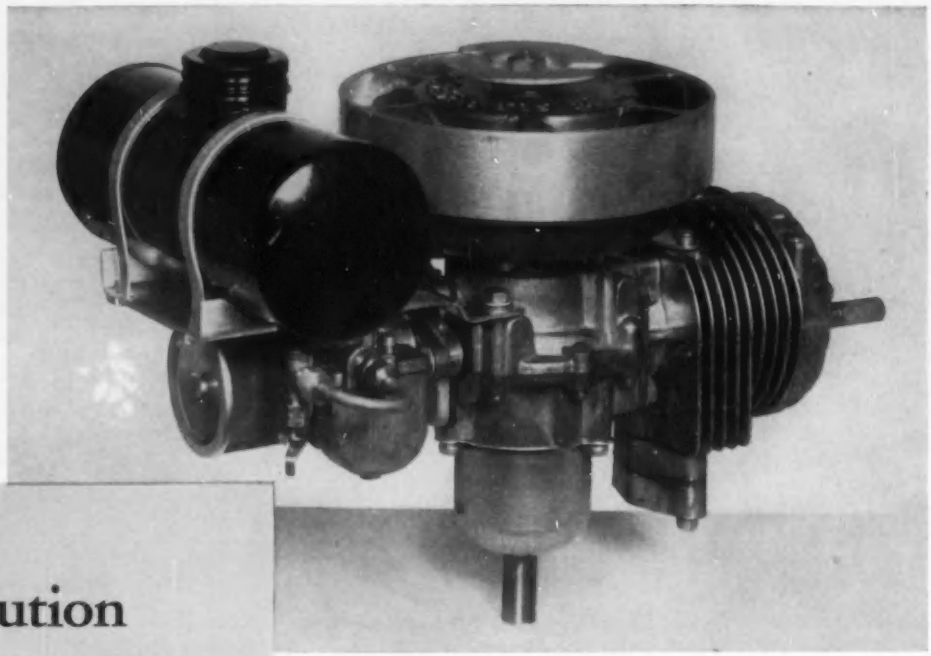
TO SELECT spindle speed, rotary pendant dial positions a pin drum with respect to plate-mounted switches, shown above. Interlocking lever when brought from horizontal to upper position, rotates gears, which through racks (shown right) separates switch plates (not shown) from the drum, permitting dial adjustment. Spindle cannot be rotated until spindle speed lever is locked.



MAIN MOTOR drives the headstock through hydraulic coupling and V-belts; the spindle and feed works are separately driven from the headstock. The head and table, saddle and spindle are driven from the feed works through respective feed screws. Four-way solenoid valves are manifolded on the pressure plate in the hydraulic tank unit; the honeycombed pressure plate eliminates piping, is part of hydraulic reservoir. The solenoid-controlled hydraulic cylinders actuate the clutch shifting rods connecting to the headstock and feed works. Hardened tooth clutches are used in feed drive, and friction cone clutches in traverse; spring-loaded safety clutches in the feed transmission rattle when overloaded. When one shifting rod leaves normally neutral position, a cross pin is forced into detent in opposite rod, preventing rods from cross-engaging. Machine feed rate can be changed from in. per min. to in. per rev by shifting the feed works drive from headstock to spindle, effected by hydraulically-controlled clutching.

TWO SEPARATELY HOUSED ROTARY PUMPS mounted on common motor driveshaft supply the hydraulic and lubrication systems respectively. The spindle back gearing can be engaged for either low or high speed range; the rack-type spindle drive is engaged when fine feed control is desired. Pressure to the head counterbalance cylinders (not shown) is supplied through an adjustable relief valve.

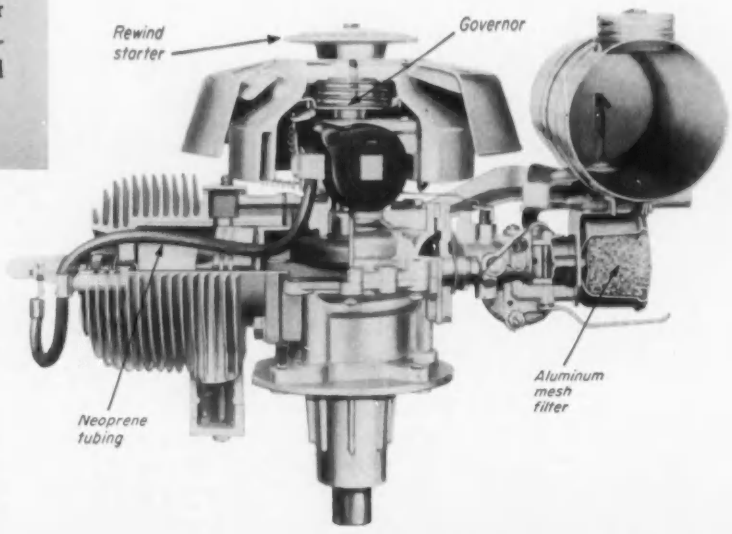




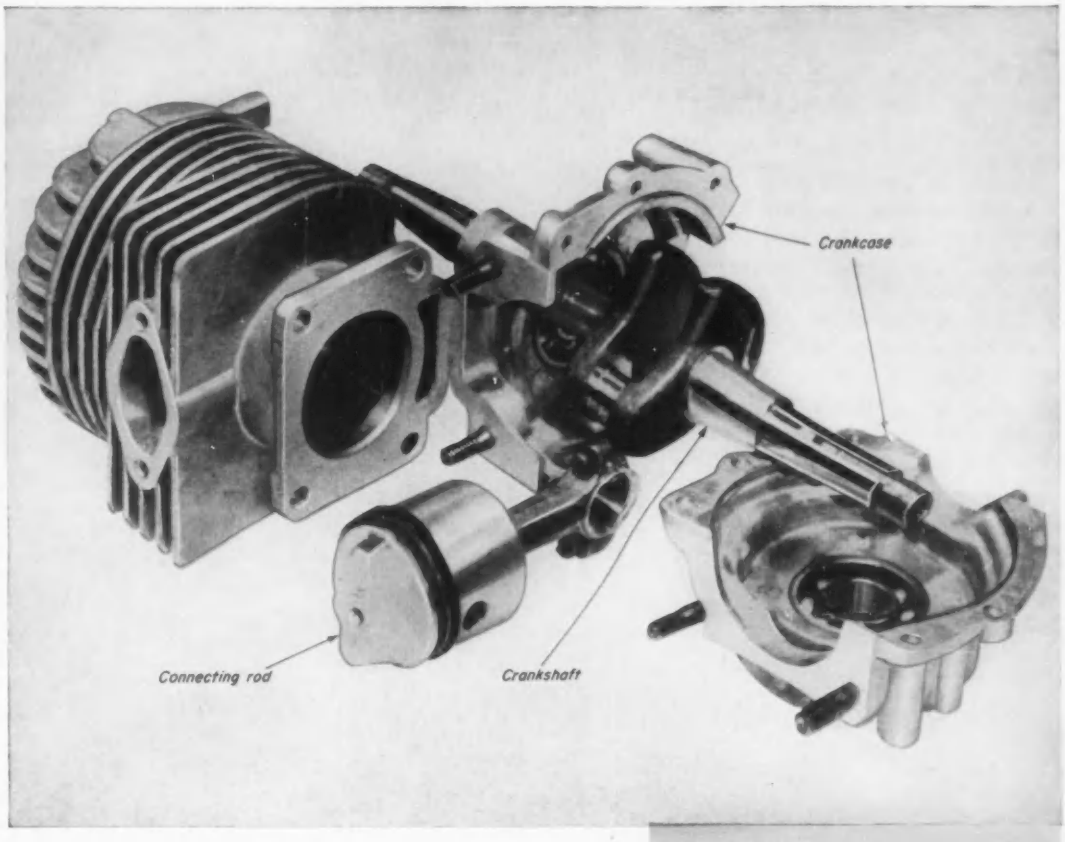
Evolution of an Engine

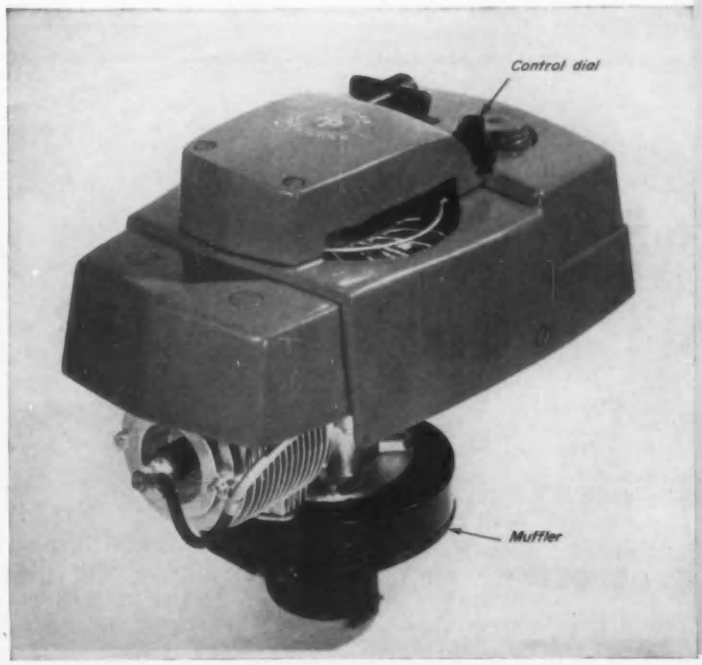
Power Products Corp., Grafton, Wis., founded in 1946, designs and manufactures 2-cycle industrial gas engines. Operation began in two-car garage; today the company owns and operates two plants totalling 1200 employees. One factor responsible for this growth has been the development of a 2-cycle power mower engine, engineered for maximum efficiency, light weight and serviceability.

R. T. LUELOFF and **R. G. KRUEGER** saw need in the original equipment market for a light weight industrial engine. First units had horizontal take-off shafts, served general purpose applications. In 1949 rotary-type lawn mower was introduced, need was established for a 2-cycle engine suitable for direct drive. Engine was redesigned as shown, for vertical power take-off. Customer was given functional engine, designed to specification. This model, like earliest engine, made use of die-cast aluminum in crankcase, cylinder and piston. Also like original this engine incorporated a balanced crankshaft, flyball governor, float-feed carburetor, multiple steel reeds, and a dry-type filter (to permit engine tilting).



POWERHEAD of latest model. Flywheel which was formerly pressed steel is aluminum casting. Flyball governor once on crankshaft is now incorporated into flywheel, has fewer parts and is more accessible. Spring-loaded flyweights hinged on flywheel force up spring-loaded ring when engine is accelerated; through linkage, ring controls carburetor butterfly valve. Neoprene tubing replaced copper lines in 1952; rewind starter was added same year. Engine operates on pre-mixed fuel.



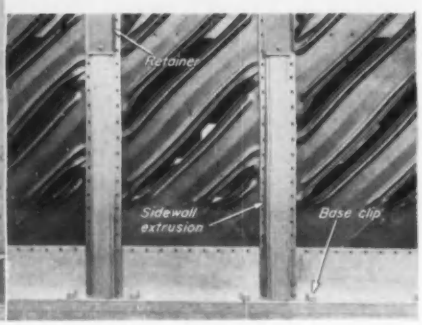


PARTS SHOWN are of a 1953 model. The $\frac{3}{8}$ in. crankshaft was mounted on ball bearings; now the forged steel crankshaft has been enlarged to $\frac{7}{8}$ in., needle bearings replacing ball bearings. Connecting rod was solid bronze in 1953 model, now is cast aluminum with bronze inserts. Split crankcase which is still used on today's model was designed to aid production assembly and servicing.

POWER has been increased by enlarging bore from original $1\frac{1}{2}$ in. to present 2 in., stroke remaining $1\frac{1}{2}$ in. Cast aluminum shroud was first added to aid cooling, now has been extended on current model to embody tank, rewind starter and cylinder for streamlined look. A 4-position dial controls start, choke, idle and stop. Not only have production costs been cut through use of die cast aluminum, company claims engine has sixty per cent less weight than many competitive engines.

All Aluminum Transport

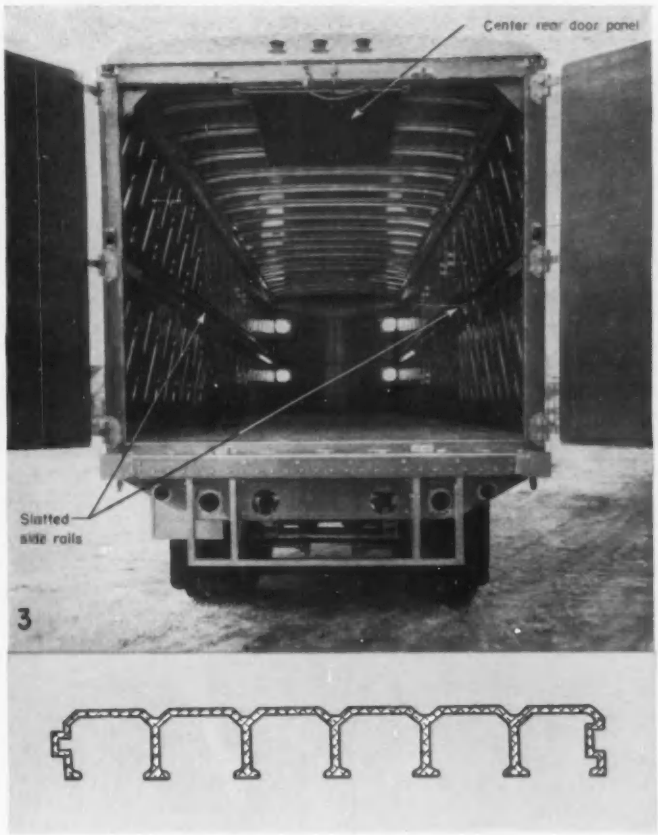
An all aluminum transport has been designed by Kaiser Aluminum & Chemical Sales, Inc., Chicago. Transport weighs about 25 per cent less than comparable steel and wood model, provides excellent ventilation and offers high resistance to corrosion, moisture and odor. Design was under the direction of Mr. C. O. Curell, chief development engineer.



Magnesium Truck Light and Rigid

A magnesium truck body weighing about fifty per cent less than a steel body of comparable size, yet sturdier and with a simplified design has been produced by the National Light Metals and Plastics Corp., Caro, Mich. The body is insulated with plastic foam and has a fiberglass interior surface, the fiberglass chosen for toughness and attractive appearance. The body was built for the Tranter Mfg. Co., Lansing, Mich., for refrigeration equipment testing.

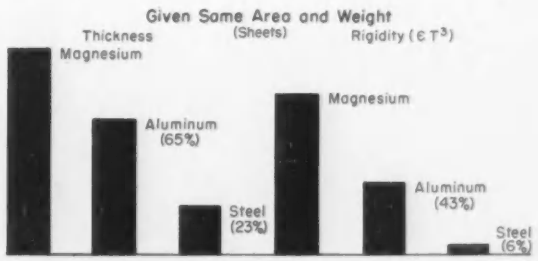
THE 12-FOOT TRUCK BODY weights 1822 lb, including duct boards and steel step bumper. Basically, the body is a ½-in. thick magnesium shell with the sheets joined by magnesium extrusions and castings. Because the thick-gaged metal provides adequate rigidity, body posts and inside corner posts have been eliminated; the thick-gaged sheets can be riveted to form watertight seals with half the rivets needed for usual thin-gaged construction.



1. This livestock transport produced by the Wilson Trailer Co., Sioux City, Iowa, is built of aluminum alloy sheets and extrusions; both welded and riveted construction is used. Only the kingpin, the landing gear jack screws and steel portions of the tandem assembly are not aluminum. Transport weighs 8275 lb, acts as single rigid beam. Aluminum's high heat reflectivity and low emissivity helps maintain low interior temperatures, and the metal's high corrosion resistance makes transport suitable for operation without paint protection.

2. Trailer with panels removed. Note how slat direction is reversed along two vertical sections of the side wall to place members in tension for greater rigidity. Close-up shows flanged and indented aluminum slats against vertical side wall extrusions; the flange provides member stiffness and ventilation openings. Panels, plywood or light aluminum, can be slipped into place between uprights and held by retainer and base clips.

3. Interior flooring is built up of extruded floor sections, shown lower inset. Sections placed parallel to body length and fixed by self-tapping screws to the underframe cross channels are joined by tongue and groove. The resulting grooved floor surface improves footing and aids drainage toward rear which lies about 1 in. lower than front. Trailer can be compartmentalized by inserting deck panels into slotted side rails.



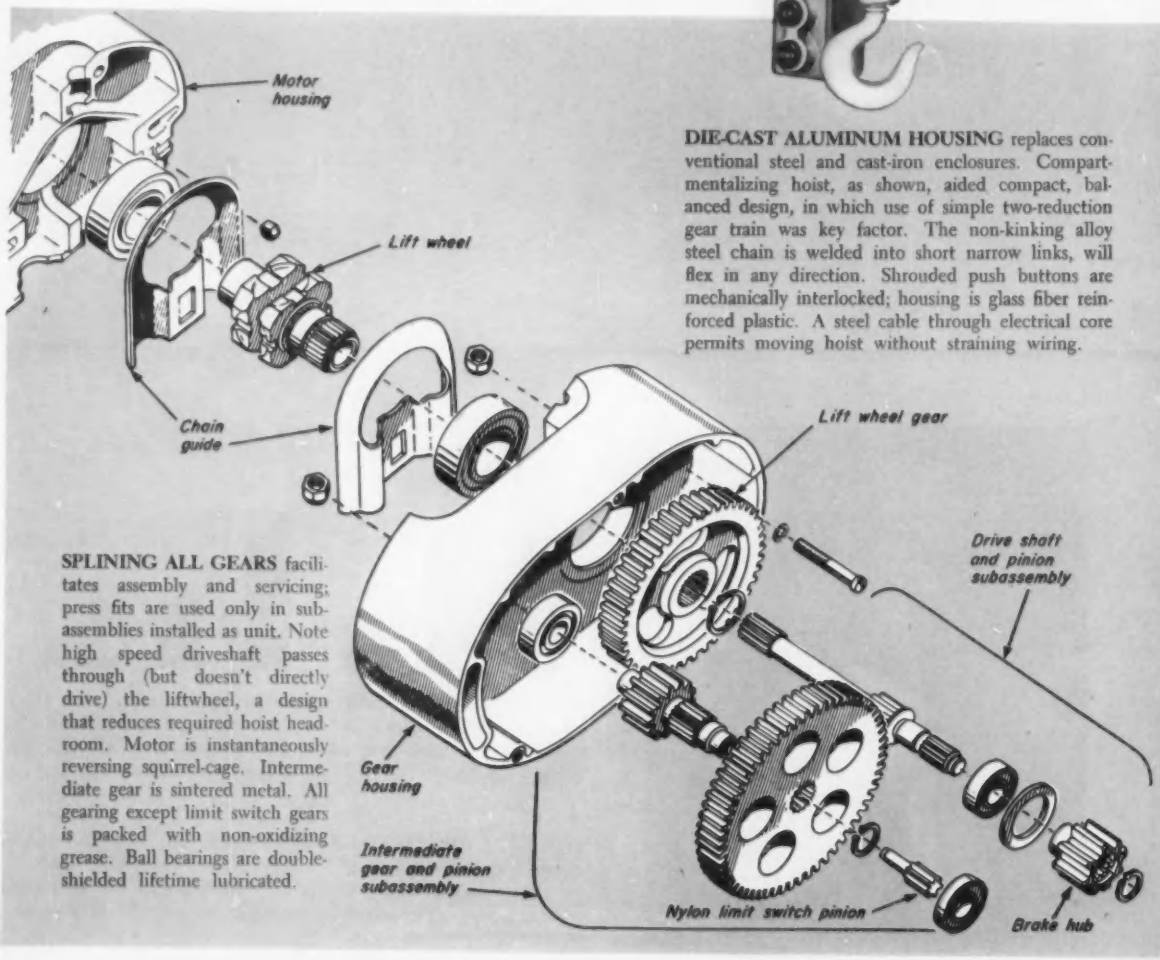
WHY MAGNESIUM BODY is light yet sturdy is shown above. Thickness is the prime factor determining rigidity of metal sheet, and magnesium is 35 per cent lighter than aluminum and 77 per cent lighter than steel.

THE SIMPLIFIED CONSTRUCTION eases installation of insulation panels, which are impaled on epoxy-coated aluminum clips bolted to the sheet. Special fitting is required only around doors and wheel housings. Styrofoam panels shown are faced with tough polyester-impregnated fiberglass.

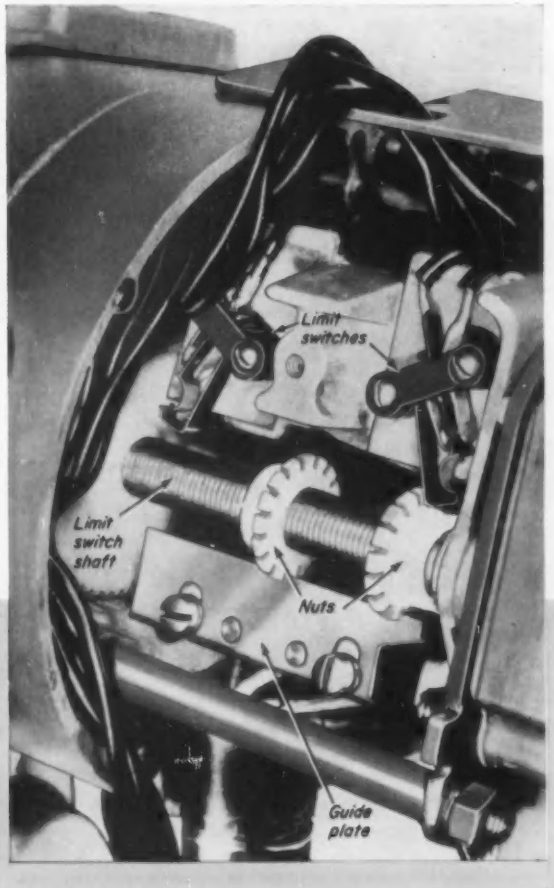
Hoist Packaged Into Compact, Low Cost Unit

A portable ½ ton electric hoist developed by Chisholm-Moore, Tonawanda, N. Y., incorporates low cost design through use of cast aluminum housings, nylon and sintered metal components. Permanent lubrication has been obtained through use of nylon parts and oil-impregnated bronze bushings in limit switch system, and by non-oxidizing gear packings.

DIE-CAST ALUMINUM HOUSING replaces conventional steel and cast-iron enclosures. Compartmentalizing hoist, as shown, aided compact, balanced design, in which use of simple two-reduction gear train was key factor. The non-kinking alloy steel chain is welded into short narrow links, will flex in any direction. Shrouded push buttons are mechanically interlocked; housing is glass fiber reinforced plastic. A steel cable through electrical core permits moving hoist without straining wiring.

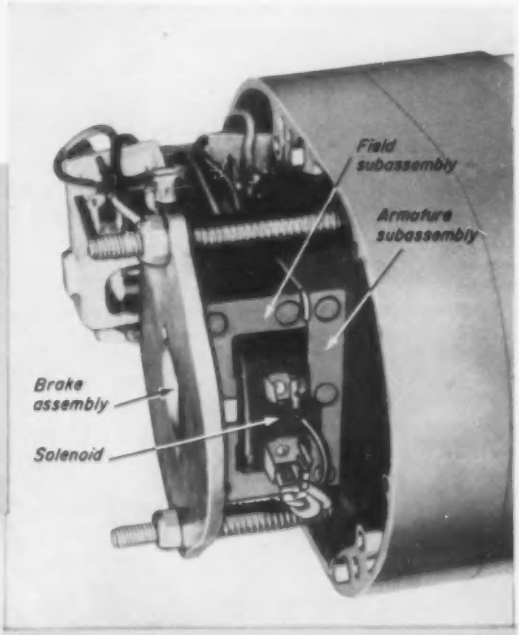


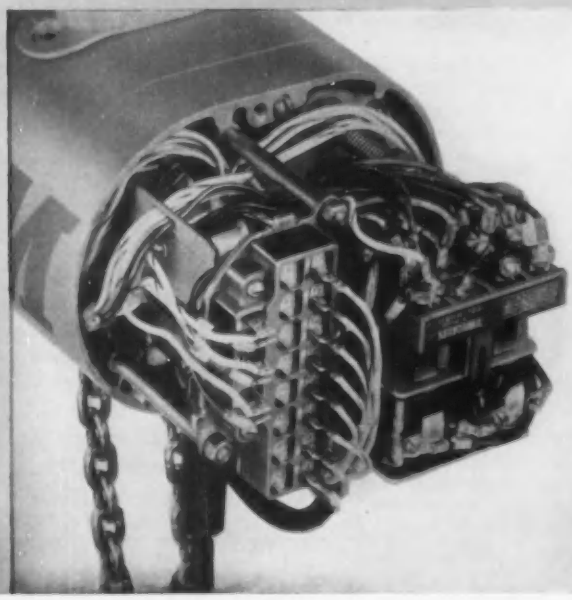
SPLINING ALL GEARS facilitates assembly and servicing; press fits are used only in subassemblies installed as unit. Note high speed driveshaft passes through (but doesn't directly drive) the liftwheel, a design that reduces required hoist headroom. Motor is instantaneously reversing squirrel-cage. Intermediate gear is sintered metal. All gearing except limit switch gears is packed with non-oxidizing grease. Ball bearings are double-shielded lifetime lubricated.



MOLDED NYLON GEARING and nuts are used in limit switch assembly, reducing costs and obviating lubrication. Limit switch shaft is mounted in oil impregnated porous bronze bushings. Limit switch is tripped by nuts which can be adjusted to stop hoist at set levels of travel.

With housing in place, switch assembly is fully enclosed. In addition, the switches are protected by a fabric cover which also serves to identify the two switches.





(ABOVE) Spring-set electric disc brake is mounted on driveshaft. When solenoid is de-energized, compression springs force iron armature plates against two discs. Motor also serves as brake during lowering; power feedback resists the tendency of the load to drive motor above normal speeds during lowering.

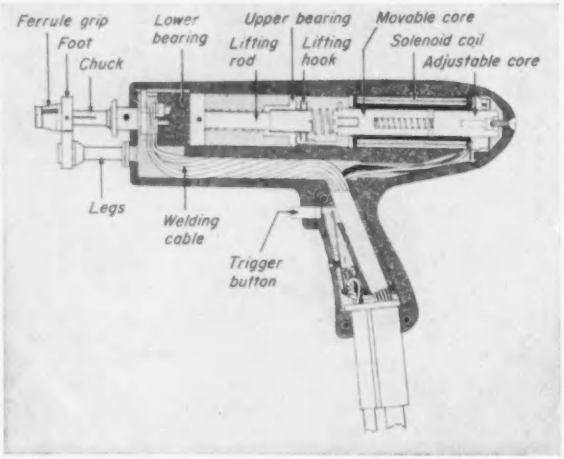
(LEFT) Color coded leads and terminals facilitate trouble-shooting. To change from 220 to 440 V, the eight conductors are transferred from left to right hand terminal position, reconnecting motor and transformer primary.

Sturdier, More Flexible Welding Gun

The NS-9 Gun designed by Nelson Stud Welding Div., Gregory Industries, Inc., Lorain, Ohio, incorporates a two-coil solenoid that operates independently of the weld current. Stud capacity is increased, more accurate arc gap control obtained.

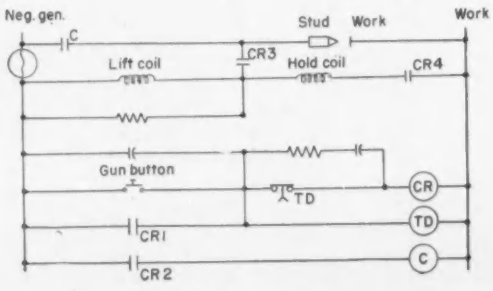
IN PREVIOUS MODEL, the single solenoid coil was energized by the weld current; because weld current increases with stud size, stud capacity was limited by size of solenoid. In new model shown, one solenoid coil (high tractive force) lifts stud, second coil (low tractive force) holds stud; the two coils are wound on a common nylon bobbin.

Phenolic plastic was chosen for gun body on basis of impact strength, ease of molding and for electrical insulation characteristic. Steel tube maintains bore alignment, provides shell for solenoid coil, and mounts lugs that support leg cores in molding. Varying stud lengths can be accommodated by adjusting legs along length of cores.



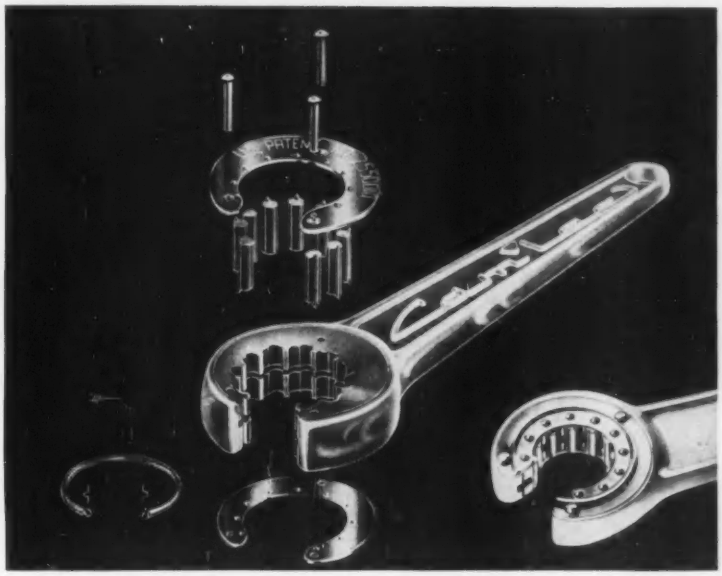
(ABOVE) When lift coil is energized, movable core is drawn back to adjustable core, to close air gap. The lift hook, attached to the movable core, pulls back, drawing back the spring-loaded lift rod. This lifts stud from work plate, striking arc. At the end of weld cycle, springs return rod and core to forward positions, plunging molten end of stud into molten pool on plate. Arc length can be changed by adjusting the air gap between the two cores; the adjustable core is screwed in and out.

(BELOW) Depressing the gun button energizes relay coil CR, closing contacts CR 1, 2 and 3. With the stud touching the work and contactor coil C open, full open-circuit power source voltage is applied across the lift coil, lifting the stud and initiating a low current arc. The contacts of coil C, energized simultaneously with the lift coil, close just after the stud is lifted, shorting out the lift coil and establishing the full welding current arc. A voltage equal to the arc voltage across the hold coil keeps the stud away from the work plate until CR is de-energized by the pneumatic timer TD. The stud is brought in contact with the work plate before weld current stops, to prevent molten metal solidifying prior to seating stud in weld puddle, accomplished by de-energizing the hold coil slightly ahead of C. The solenoid has faster drop-out characteristics than C, with resilient contacts on CR.



Cam Mechanism Reduces Lost Motion

During World War II, Al Kavalar, chief engineer of The Kramer Fabricating Co., Detroit, Mich., noted the need for a ratchet wrench with a short arc-swing to tighten tube fittings and similar connectors. A direct acting trigger, used as a ratchet mechanism, was incorporated in a standard open-end wrench to produce the required tool.



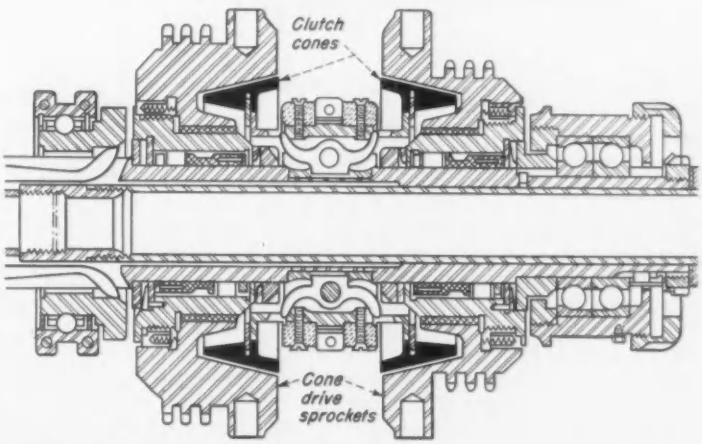
ROLLER-CAMS, riding in lobes machined in wrench jaw are held against the nut by a single garter spring. Each roller is eccentrically notched to develop the rolling cam action which grips the nut and transmits torque to the wrench body. Use of a single spring equalizes torque transmitted by the rollers.

Close spacing and direct action of rollers on nut provides short ratcheting arc swing and eliminates most lost motion common to ratcheting tools. Lost motion does not increase as rollers wear. Wrench will adjust to badly burred or heavily painted nuts and will not mar chrome fittings.

Designated "Cam-Loc", this new wrench provides faster, more efficient operation in the assembly, installation, maintenance and repair of air conditioning, heating, refrigeration and plumbing units.

Plastic Clutch Cone Resists Heat

Time lost reversing some of their automatics led Brown and Sharpe to use a high speed reversing clutch with movable cones of a phenolic plastic. Developed by Synthane Corp. of Oaks, Pa., the material is prepared by macerating phenolic resin impregnated cotton cloth which is then molded into cones having excellent heat resistance and a good weight-strength ratio.



THE SUCCESS OF THIS DESIGN is attributed to the lightweight, strength and heat resistance of the macerated molded phenolic material used in the cones. Positive production operations require strong spindle drive clutch. Rapid reversal demands low inertia, requiring a light movable element. Molding clutch cone integral with steel plate produces simple, rugged design. Although operating temperatures of 250 deg F. develop under this severe service, the molded clutch cone provides smooth, positive action and freedom from distortion or deterioration.

How the

German Standards Bureau

Serves Science and Industry

Oldest of all national bureaus of its kind, its history goes back to 1887 but the present organization and most of the buildings, grounds and equipment date from 1947. Here is how the Germans, starting from scratch, operate their equivalent of the United States National Bureau of Standards.

President of the Institute, Professor Dr. Richard Vieweg.

RICHARD VIEWEG
Braunschweig, Germany

In 1887 the German Physical Technical National Institute was organized under the direction of Hermann von Helmholtz at Berlin-Charlottenburg. The creation of this German state laboratory was epoch making. This was the first time in the world's history that the idea of official standards of measurement became a reality. It was thereby established that it was to be a function of the state to make it possible for its industry and its economy, its technology and indeed each of its citizens, accurately to measure anything that is amenable to physical measurement.

Some years after the establishment of this institute in Germany there appeared, patterned along the same lines, government laboratories in other countries. The largest of these included the National Physical Laboratory at Teddington near London, (1900) in Great Britain, and the National Bureau of Standards at Washington, D. C. (1901) in the United States of America. Similar institutions were established in France, Russia, Japan, Canada, Australia and other countries. Today even countries that have in the past been slow in scientific and technological development are endeavoring to install government testing stations which are at the same time to serve as germ cells of scientific research and technological progress.

The National Institute continued in operation until the general breakdown in Germany in 1945. Two years later in 1947 its successor (with respect to the territory of the German Federal Republic) was organized at Braunschweig and in 1950 the reorganized association was given its present name, The Physical Technical Federal Institute (PTB). Three years later the remnants of the old installation in Berlin-Charlottenburg and still bearing the old name, became the Berlin Institute of the Physical Technical Federal Institute.

Scope

In some respects the fields of activity of the German Federal Institute parallel those of the United States Bureau of Standards. The German Bureau is responsible for the creation, preservation and improvement of unit standards

VIEW OF THE MAX-WIEN-TOWER and a portion of the buildings in which the laboratories of the electricity and acoustics are housed.

of measurement in physics and engineering and it is the duty of this federal institution to check the uniformity of such measures. This involves the whole field of physics.

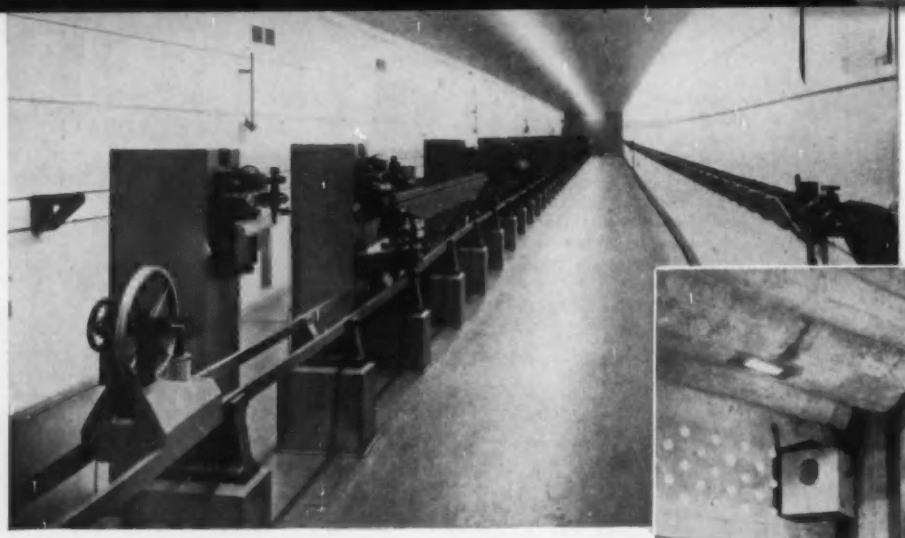
The Federal Institute is at the same time the paramount inspecting authority in the field of verification and calibration and therefore cooperates with the verification boards of the German federal states. Similar functions connect the PTB with about 60 Electrical Testing Stations within Federal territory with nearly 200 extension stations. These perform functions comparable to those of the Underwriter's Laboratory in the United States, but within the framework of the Federal Institute. The Institute is responsible for deciding on admission of instruments for approval or calibration, as well as on authorization of instruments for use in trade. Proposed codes and legislative bills in the field of calibration and units are likewise within its jurisdiction. International commitments of the Federal Republic in the domain of official measurement, and representation of the Republic on bodies within the General Conference of Signatories to the Meter Convention, the International Bureau of Weights and Measures, and others are carried out by PTB.

Mechanics

The scope of Division I, Mechanics, can be described by naming two main functions of special importance; definition and preservation of the units of time, length and mass, and testing and licensing activities according to the German Weights and Measures Statute. Nineteen laboratories perform these functions.

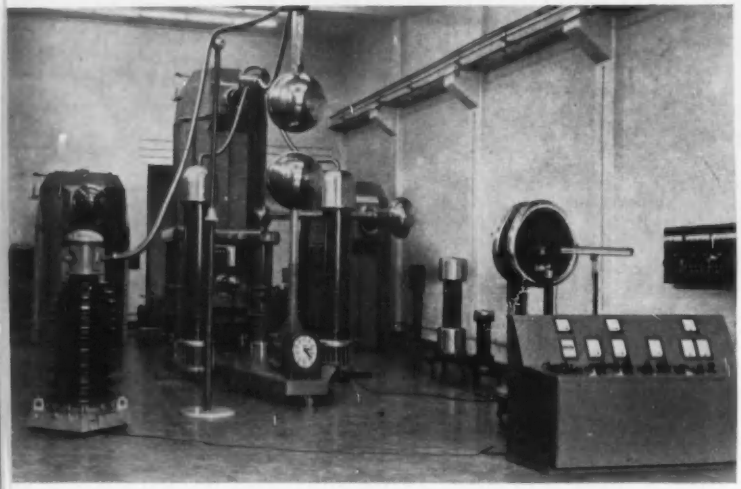
Closely related to the fundamental units are the derived units of frequency and force. Research and industrial production require that these units be consistently determined with the highest precision attainable by modern science. This precision determines the ultimate limit of precision of all other derived physical units. Experimental resources needed for such work are most extensive.

The unit of length is internationally defined by a platinum-iridium bar preserved at Sevres, on which the various national standards are based. The Federal Republic recently obtained again its own national copy (No. 23). The latest trend of development is to define the meter in terms of the wavelength of light. The PTB is playing a leading part in extensive scientific researches to this end. The Federal Republic now has a national copy of the standard of mass also. This copy, No. 52, is kept accessible by the PTB to qualified national agencies. Testing and licensing under provisions of the Weights and Measures Statute is very inclusive. It embraces type testing of balances of all kinds, liquid and gas meters, length and area measuring devices, and motor transport instrumentation. Modern developments like the application of electronics to balance design keeps posing new problems. The laboratory for mechanical premium ma-



THE MEASURING SECTION for the comparison of lengths at the Federal Institute.

ROOM FOR PROVING sound-deadening materials and the measurement of noise levels



HIGH VOLTAGE installation at the institute for the testing of construction materials for current and voltage transformers.

chines stands somewhat apart from activities as a whole. It is charged with the licensing of mechanical premium devices and coin machines.

Electricity

In the field of electrophysics and electronics, the PTB recognizes four sectors of paramount public interest. These are units, official testing, materials constants, and high-frequency physics.

Definition and maintenance of basic electrical units (the ohm, volt and ampere) is a legal duty of the PTB. Relation of the basic units to the physical system of units is the function of one of the 14 laboratories of Division II, Electricity; another takes care of the derived units (e.g. of capacitance and inductance). Of great importance are comparisons with the units of foreign government institutions and coordination with the international ohm or volt defined by the Bureau International des Poids et Mesures, at Sevres. The uniformity of electrical measurements throughout the civilized world is maintained in this manner.

In the field of materials constants, the electrical and magnetic properties of materials are determined. This includes measurement of magnetic constants in direct and alternating current, as well as determination of dielectric constants at high potentials. The testing group includes a coordinating center for electric testing stations, dealing primarily with administrative problems, as well as laboratories for meters, instrument transformers, machinery and appliances, and control techniques.

Licensing of high-frequency therapeutic devices and problems of electrical interference account for a large proportion of the current activities. Research in the development of a standard of frequency, and hence time, in the form of a so-called atomic chronometer is being carried on in collaboration with the appropriate laboratories of Division I.

Heat

The three basic thermodynamic quantities of temperature, pressure and density constitute important areas of study which include work on the relationships among the

basic quantities, the so-called equations of condition. The underlying authority derives from the Statute on the Temperature Scale and Unit of Heat of 1924.

Another field of activity is determination of all the quantities pertinent to heat exchange (heat value, specific heat, heat conductivity, heat transfer). Some of these properties display a low-temperature behavior which is significant from the point of view of physical science as a whole. This will be the province of the Low-Temperature Physics Laboratory still under construction. Viscosity is handled by the Viscosimetry Laboratory. A Chemistry Laboratory confines itself largely to research on behalf of other agencies of the Federal Institute. Because of the intimate kinship with the thermodynamic orientation of physical chemistry, it naturally fits into the Heat Division.

The three safety engineering laboratories of the Division are involved in research as well as testing. Compulsory testing of flame proof equipment and supplies is covered by this group.

Many branches of industry use combustible gases and liquids. Safety engineering research is absolutely necessary to further progress in these fields. Other safety problems arise in sporting weapons and ballistic tools for industrial purposes (riveting hammers), in which gases under high pressure provide propulsion.

Optics

Projective optics is concerned with formation of optical images by the propagation and refraction of light. Results obtained are used by the optical instruments industry. Products are tested for quality of image, state of correction, aperture ratio, resolving power, distortion, etc.

Photometry studies visible radiation for its physiological effects. The basic unit of photometry is derived from the laws of radiation from a "black body". Its measurement and duplication are fundamental problems of the PTB.

In the laboratory for measuring emission power, the energy content of radiation is defined physically, without regard to any physiological function, and measured in watts. Work extends over the entire range of the spectrum. Ultra-violet radiation receives special attention because it can be injurious to man. The infrared has likewise gained in technological importance of late, for example in radiation drying.

The laboratory for scientific photography deals with the photochemical action of light as applied in photography. A chief function is the evaluation of performance of photographic supplies. In particular, the sensitivity data on film packages are regularly verified.

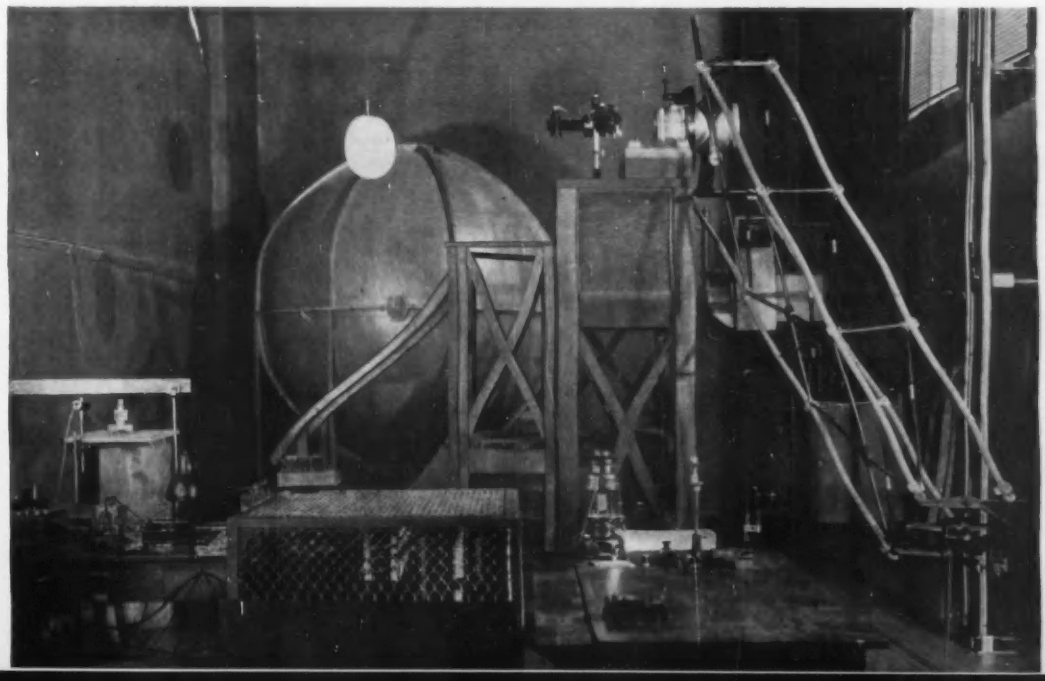
Polarimetry is concerned with phenomena involving polarization of light; one of such important phenomena is the rotation of the plane of polarization when light passes through optically active substances such as sugar solutions. This provides a simple, accurate and rapid method of determining sugar content. The work of this laboratory provides sugar technology with the bases for price calculations.

Spectroscopy studies the composition of light with respect to wavelength. Sources of emission and light-absorbing substances are quantitatively investigated. Line spectra (light composed of certain discrete wavelengths only) are especially important. The objective is to determine certain wavelengths with the highest attainable precision, and to improve spectroscopic techniques and instruments. Gaps in our knowledge persist especially in the infrared range of the spectrum.

Acoustics

Acoustics, as the study of sound as a form of physical energy, and as auditory perception transmitted by the ears has become of great significance in the last two decades as a result of the rapid progress of electronics. This prominence is reflected in the seven acoustic laboratories of Division V. Duties include the fixing of acoustic

PHOTOMETRY LABORATORY with the Ulbricht sphere and the apparatus for measuring light intensity.



units and standards, the determination of sonic pressures over a wide range of frequencies and amplitudes, and exact calibration of high-quality test microphones. In devices for recording and reproducing sound, characteristic properties such as frequency shift, interference noise, distortion and synchronization are measured. For sound recordings outside the PTB, a mobile unit equipped with magnetic recording devices is available. Detailed investigation and frequency analysis of the recordings is conducted in the laboratory.

Modern electroacoustical techniques have also led to many discoveries concerning musical tones and instruments. Here again, quantitative physics has conquered a domain in which accidents of architectural planning often determined acoustical conditions.

Another important problem investigated in the Acoustics Division is interference sound as represented by noise due to traffic, in industrial plants and in construction. To an increasing degree, this requires measurement of solid conduction of sound and vibration.

Acoustical problems make contact with medicine at many points. Thus calibration of audiometers facilitates proper diagnosis of diseases of the ear. Characteristics of electronic hearing aids, ear protectors and cardiographs need to be tested. Ultrasonics have gained importance in the medical field. Medical devices using supersonic waves are inspected.

Acoustic techniques are used to determine dynamic properties of materials. Special attention is being devoted to substances of high internal absorption, used for so-called soundproofing materials applied to machine parts and sheetmetal structures. Methods have been developed for measuring the dynamoclastic constants of high polymers over a wide range of frequencies and temperatures. Such research yields insight into the molecular structure of the high polymers studied.

Atomic Physics

The work of the youngest Division of the Federal Institute, Division VI, Atomic Physics, can be divided into two areas; one embracing the field of ionizing radiation, and the other certain techniques of measurement and research in atomic physics.

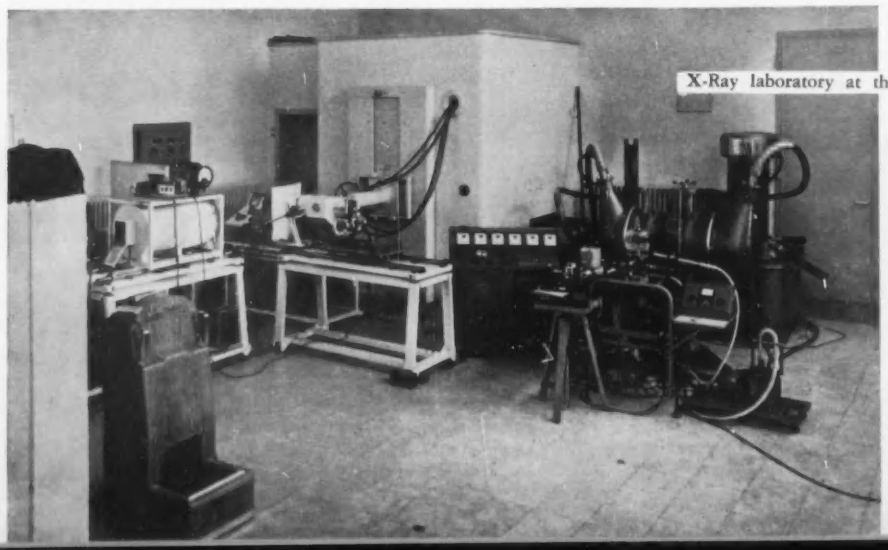
Ionizing rays, particularly the emanations of radio-active substances, X-rays, high-energy electron rays and neutron rays, are now used for many purposes in medicine and technology. The Federal Institute is concerned for example with the general dosimetry of such radiation and determinations of quantities of radioactive substances. Solution of these problems requires not only the definition of units and developments of technical procedures but also testing and improving of instruments and techniques of medicinal dosage and surveillance of radiation safety in the vicinity of radioactive equipment and supplies. Testing devices for air pollution have lately been added. Work on these practical problems must necessarily be supplemented with a considerable amount of physical research in the field of ionizing radiation of all kinds, atomic nuclei and their constants. These problems are handled by the Radioactivity, Radiology, and High-Energy Radiation Laboratories.

Laboratories in the second group serve general needs of the Federal Institute, and also to some extent to third parties. At the same time, however, further development of measuring methods and fundamental research is an obvious concern. Work is being done in electron microscopy, electron optics, X-ray analysis of microstructure, fundamentals of electronic emergence from surfaces and its practical applications to materials testing, quality control, and a laboratory for mass spectrometry is being organized.

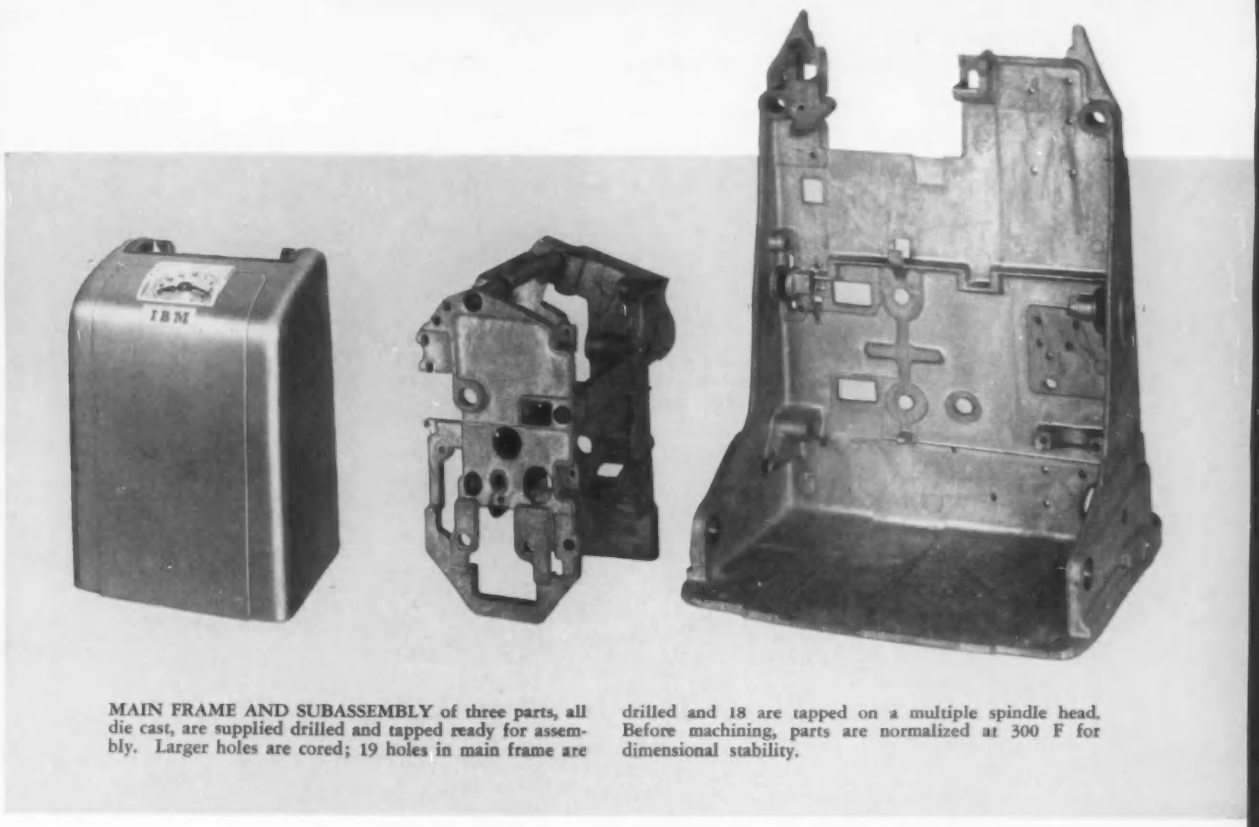
The Berlin Institute

The Berlin Division serves the needs of the State of Berlin, and represents a "miniature PTB" in itself. Scientific research is given the same emphasis at Berlin as at Braunschweig. Although the definition and establishment of units is concentrated at Braunschweig, scientific progress in physics is indispensable to the Berlin laboratory program. In the field of electrical standards, however, the institute occupies a special position in the definition of units because Weston cells are produced to a large extent in Berlin.

The importance of close cooperation between the experts of the Braunschweig and Berlin parts of the Institute is obvious. The numerous laboratories and activity fields are of great advantage and it is possible to get an expert's consultation easily right within the plant.



X-Ray laboratory at the institute.



MAIN FRAME AND SUBASSEMBLY of three parts, all die cast, are supplied drilled and tapped ready for assembly. Larger holes are cored; 19 holes in main frame are drilled and 18 are tapped on a multiple spindle head. Before machining, parts are normalized at 300 F for dimensional stability.

Time Clock Frame

R. I. TRAVIS
Manufacturing Engineer, Tool Engineering Div., International Business Machines Corp.

WE HAVE NO PAT FORMULA for determining by what process a part should be made. After a product has been developed, it goes to our Market Analysis Department, which prepares a sales forecast with the assistance of the Sales Department. This forecast is then given to Product Design, and estimated production is determined on the basis of a yearly and a total part life without major design changes. Material specification is made by the product designer and various production processes are weighed. Manufacturing Engineering provides an estimate of machining time required for alternative processes. After the process is selected, Purchasing secures quotations from vendors who work with Product Design in making desirable and economical design changes.

For a part that could be either sand cast or die cast with comparable cost, the process most susceptible to easy design changes may be selected. Also, sand castings may be used to get initial production on the market quickly or to get units out for sales testing. Die casting is generally used when quantities are higher or are likely to increase; when the process eliminates substantial machining, or uniformity is mandatory, or minimum wall thickness is desirable; and to reduce the cost of surface preparation before plating or painting.

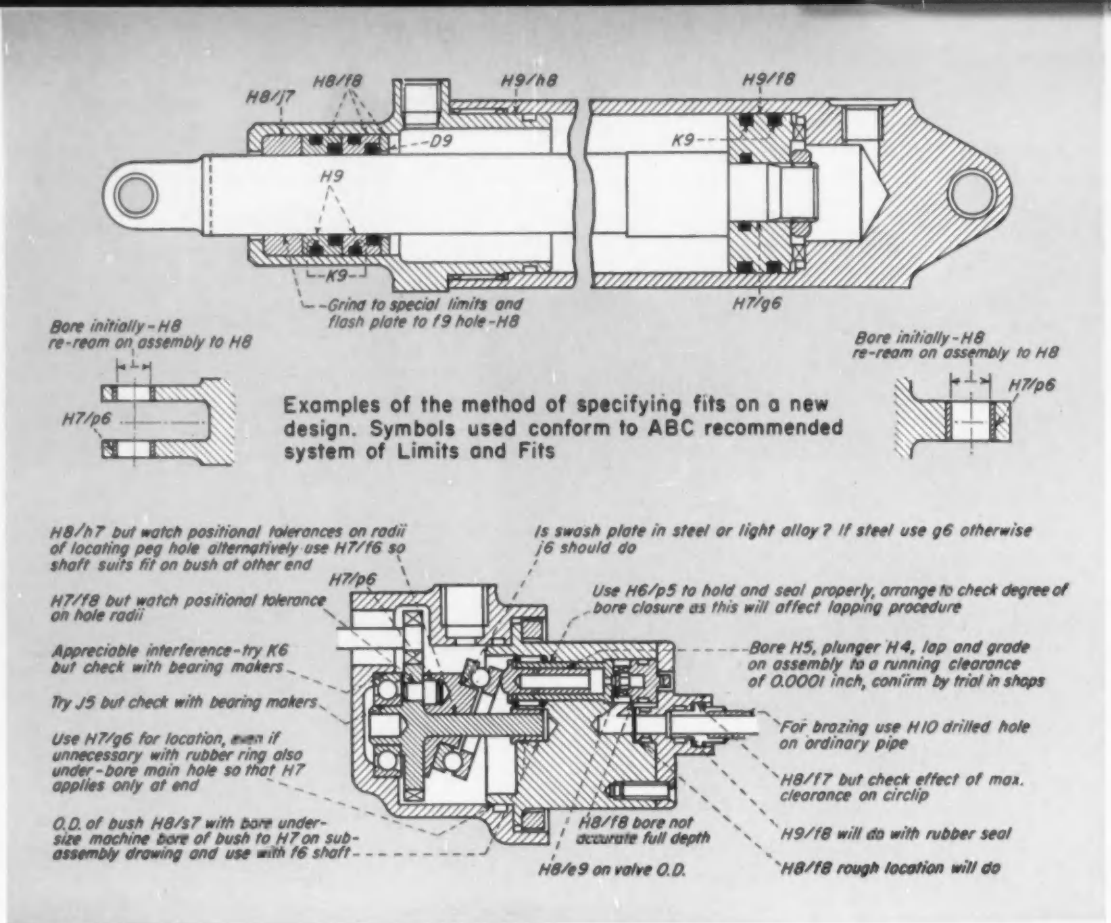
A typical typewriter has about twenty die cast parts, and a lesser number of sand castings. The frame is die cast to eliminate machining and forming, and to reduce weight; if sand cast or plaster molded, the piece cost would be higher. The cover is also a die casting, for uniformity and finish, and to obtain minimum wall thickness—0.080 in.; for a stamping, the draw would be difficult, tooling would cost more, and assembly of components would increase piece cost.

In redesigning a sand casting to die casting, we eliminate undercuts and watch the proportioning of wall thickness, reducing it wherever possible. We save on machining and drilling of many tapped holes; many surfaces requiring stock removal in sand casting are satisfactory in die casting.

EDITOR'S NOTE—See also "Redesign for Die Castings" in January 1956 *Product Engineering*, page 156.

CORRECTION

Through error the weight of the die-cast Nash radiator grill pictured on the January cover was given as 30 lb; the weight actually is only 9.5 lb.


H8/f8
H9/h8
H9/f8
H8/f7
D9
K9
H9
K9
Grind to special limits and flash plate to f9 hole-H8
H7/g6
Bore initially-H8 re-ream on assembly to H8
H7/p6
Bore initially-H8 re-ream on assembly to H8
H7/p6
Examples of the method of specifying fits on a new design. Symbols used conform to ABC recommended system of Limits and Fits
H8/h7 but watch positional tolerances on radii of locating peg hole alternatively use H7/f6 so shaft suits fit on bush at other end
H7/f8 but watch positional tolerance on hole radii
Appreciable interference-try K6 but check with bearing makers
Try J5 but check with bearing makers
Use H7/g6 for location, even if unnecessary with rubber ring also under-bore main hole so that H7 applies only at end
O.D. of bush H8/s7 with bore undersize machine bore of bush to H7 on sub-assembly drawing and use with f6 shaft
H7/p6
Is swash plate in steel or light alloy? If steel use g6 otherwise j6 should do
Use H6/p5 to hold and seal properly, arrange to check degree of bore closure as this will affect lapping procedure
Bore H5, plunger H4, lap and grade on assembly to a running clearance of 0.0001 inch, confirm by trial in shops
For brazing use H10 drilled hole on ordinary pipe
H8/f7 but check effect of max. clearance on circlip
H9/f8 will do with rubber seal
H8/f8 rough location will do
H8/f8 bore not accurate full depth
H8/e9 on valve O.D.

The Use of Tolerance Systems

TOLERANCE SYSTEMS and tables of limits and fits are intended to supply a standardized series of fits on drawings, thus restricting the number of limit gages which are required for production to these drawings. The new ABC System of Limits and Fits, agreed upon between representatives of America, Britain and Canada in 1953, and now under consideration as an American Standard, gives a wide variety of tolerances and fits for all types of engineeering products from fine precision components to rough manufacturing processes. There are also tolerances which may be of use for specialized fabrication methods such as casting, molding, sintering, pressing, etc.

The Selection of Tolerances

The selection of appropriate tolerances for a new machine design involves several factors of prime importance:

(a) The type or class of product (i.e., an aero engine or an agricultural machine).

(b) The skill and experience of the engineer selecting the tolerance.

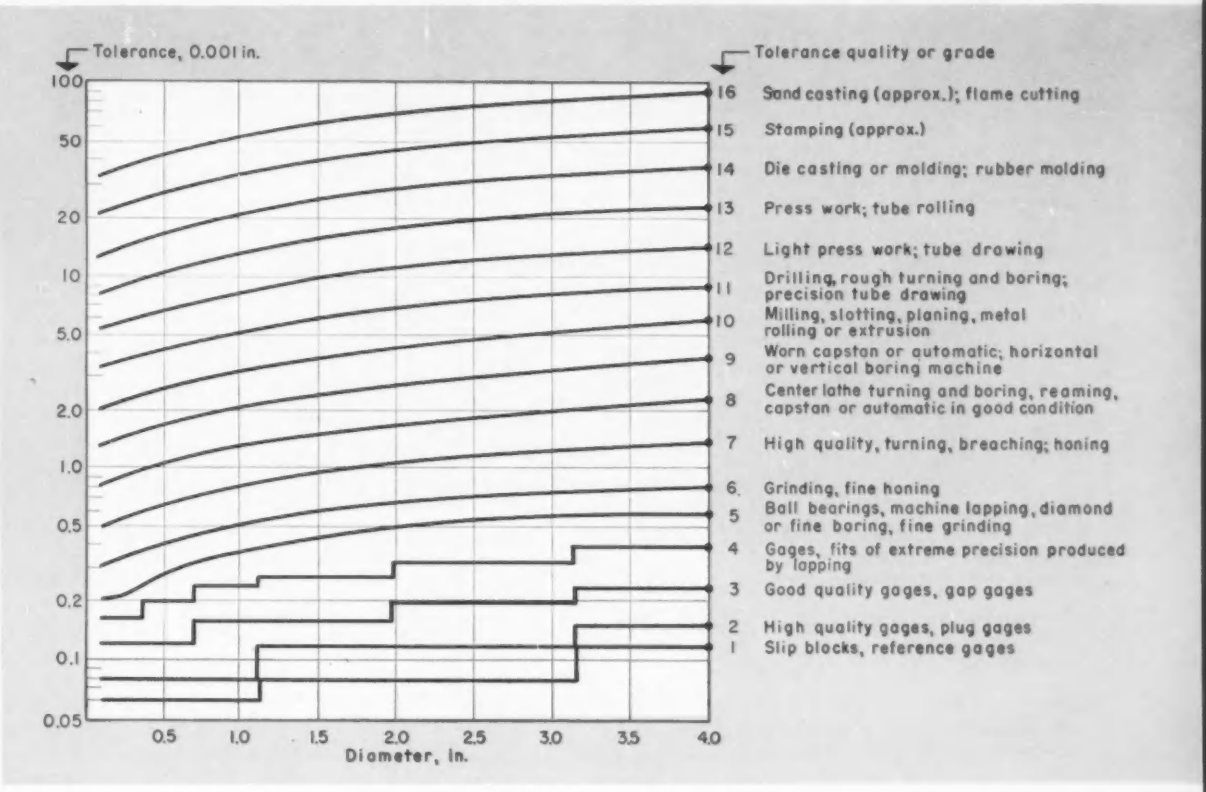
(c) The machines and plant with which the design must be manufactured.

(d) The degree of interchangeability which must be achieved.

Class of Product

Tolerances should obviously be as coarse as possible consistent with satisfactory performance of the machine. The difficulty that the design engineer meets is that he rarely knows the absolute limits of tolerance at which the machine will work; in fact, it is common experience that nearly all machines work perfectly well with much broader

Fig. 1—The degree of accuracy which can reasonably be expected from various machine processes under average conditions.



H. G. CONWAY
Short Brothers & Harland Limited, Queens Island, Belfast, Ireland

An introduction to the use and selection of tolerances and fits, with particular reference to the new ABC tolerance system. Tables of tolerances for shafts and holes plus recommended clearance, transition, and interference fits are included.

tolerances than allowed on the drawings. The designer invariably plays safe and errs on the side of closeness of tolerance, which means more costly manufacture. However, what may be necessary on a precision product (an aero engine, a high pressure pump, a watch mechanism) is not required on the average machine (a mowing machine, a mass-produced automobile, an electric hoist); and what is suitable for the average machine will be too good for a simple, little used machine (a disk harrow, a gate hinge, a pulley block).

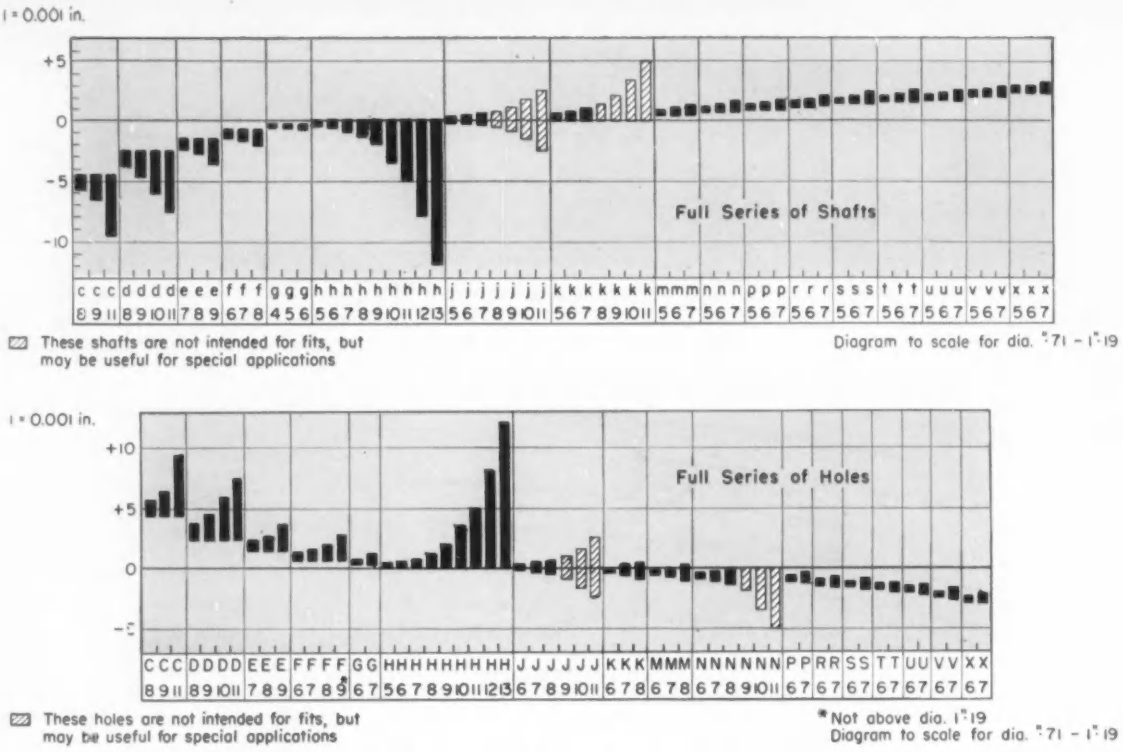
Engineer Who Selects Tolerances

Engineers know the difficulty of collecting and tabulating recommendations for the selection and use of tolerance. Circumstances vary on every engineering design and fits suitable in a particular place on one machine may not suit an almost identical machine because of a difference in size, speed, temperature, material or other relevant factor.

Only the experienced engineer is able to select tolerances scientifically and effectively. Since in any design office there are only a limited number of men with the necessary experience, a degree of specialization may be required. Whether a special tolerance section is required in the office depends on the variety of work passing through, and the size of the office. In most cases, however, the best practice will be as follows:

(a) A limited number of senior engineers (if not the Chief Engineer or Chief Designer) should be responsible for all tolerance selection.

(b) Where general designs are standardized, a "tolerance selection table" for general use in the design office


1 = 0.001 in.
+5
0
-5
-10
Full Series of Shafts
c c c d d d d e e e f f f g g g h h h h h h h h h j j j j j j k k k k k k k k m m m n n n p p p r r r s s s t t t u u u v v v x x x
8 9 11 8 9 10 11 7 8 9 6 7 8 4 5 6 5 6 7 8 9 10 11 12 13 5 6 7 8 9 10 11 5 6 7 8 9 10 11 5 6 7 5 6 7 5 6 7 5 6 7 5 6 7 5 6 7 5 6 7
These shafts are not intended for fits, but may be useful for special applications
Diagram to scale for dia. ".71 – 1".19

1 = 0.001 in.
+10
+5
0
-5
Full Series of Holes
C C C D D D D E E E F F F F G G H H H H H H H H J J J J J J K K K M M M N N N N N N P P R R S S T T U U V V X X
8 9 11 8 9 10 11 7 8 9 6 7 8 9 6 7 5 6 7 8 9 10 11 12 13 6 7 8 9 10 11 6 7 8 6 7 8 6 7 8 9 10 11 6 7 6 7 6 7 6 7 6 7 6 7
These holes are not intended for fits, but may be useful for special applications
* Not above dia. 1".19
Diagram to scale for dia. ".71 – 1".19

Fig. 2—Letter and number symbols determine tolerance width and band locations. "Hole Basis" fits use the series H holes with shafts chosen to give the desired fit.

should be prepared and used for drafting room reference.

(c) Whenever practicable, selection tables should be supplemented with specialized illustrated recommendations.

(d) Before detailing, new designs should pass through the hands of a senior engineer. Each office will have its own method of handling this procedure but in one method an advance print of the new design is marked up by the specialist with his recommendations. The practical discussion and, indeed, argument which will take place about these proposals will be of benefit both to the senior engineer and the individual designer. In many organizations the marked-up print will be routed through a production office to obtain advance concurrence from those responsible for manufacture.

Machine Capabilities

It is true that the tolerance and fits which a product requires are not primarily related to the tools with which the machine will be manufactured. However, the machine designers must produce designs which can be manufactured in the plant at their disposal, and they must therefore have a knowledge of the degree of accuracy which is producible with various categories of machines.

Fig. 1 based on a diagram issued in the British version of the ABC Tolerance System Standard, gives information on the approximate capabilities of various common types of machine and process. This information does not represent the absolute accuracy that a particular machine can achieve when in good condition or in the hands of a skilled operator; it is what an average machine can do in the hands of an average operator. No conscientious designer will, for example, issue drawings of small bar parts for some design which he intends to be easy to produce, with diameter tolerances of 0.0005 in. when he knows that a normal turret lathe requires 0.002 in. But he must maintain a sufficiently close liaison with the production department to find out if close tolerances are preferred on a shaft, enabling a wider tolerance to be used on the hole (with easier reaming) for the same class of fit.

Degree of Interchangeability

Too high a degree of interchangeability on the components of a product will involve excessive cost. Even the modern automobile uses many parts which must be set or adjusted at assembly or are chosen by selective assembly. To make all pistons and piston rings fully interchangeable would involve extravagantly close control of tolerances even with the machine tool equipment available in Detroit. In the normal engineering shop, it is more economical to rely on a small amount of fitting, selection, adjustment, shimming or some other process to achieve assembly interchangeability. The degree of interchangeability which will be most suitable for a particular design is therefore a factor to be determined by local conditions and recommendations for tolerances and fits made accordingly.

Types of Tolerance and Fit

Fits are governed by the tolerances on shaft and hole as well as by the relative location of these two tolerance bands. The ABC tolerance system establishes a series of tolerance grades based on a mathematical formula and numbered such that increasing grade numbers corre-

CLEARANCE FITS

Fit Designation	Association of Hole and Shaft	
LC1 LC2 LC3 LC4	H6/h5 H7/h6 H8/h7 H9/h9	Here the upper shaft limit is zero and therefore the same size as the hole lower limit. In practice the probability is that the fit will be one of slight clearance. This fit is widely used for non-running parts, such as bolts, or even parts which must occasionally rotate (particularly on cheaper products). It is useful also for normal location or spigot fits.
RC1 RC2	H5/g4 H6/g5	Fit with least clearance, the minimum clearance being rather small for a normal working bearing. It is intended for close location fits.
RC3 RC4 LC6	H6/f6 H7/f7 H8/f8	First fit intended for use as a normal working fit. It is widely used as a normal grease or oil lubricated bearing, but not necessarily at high temperature as the minimum clearance is still small.
RC5 RC6 LC7	H7/e7 H8/e8 H9/e9	Intended for use on loose clearance fits or lubricated bearings which run hot.
RC7 LC8	H9/d8 H10/d9	Intended for appreciably loose fits on less accurate work. Some of these fits are suitable for production by other than machining processes, (i.e., rolling or drawing).
RC8 LC9	H10/c9 H11/c11	Shaft of substantial clearance, not widely used.

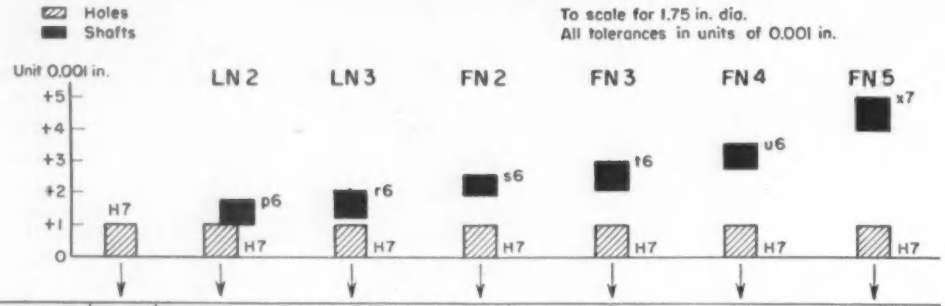
TRANSITION FITS

LT2	H8/j7	True transition fit averaging a slight clearance. It can be used on location fits where slight interference can be tolerated (i.e., assembly by light hammer blows), and where the maximum clearance must be less than with the "h" shaft, in order to improve the accuracy of location.
LT3 LT4	H7/k6 H8/k7	Transition fit averaging virtually no clearance being nearest in size to the hole H itself. It can be used on location fits where some interference can be tolerated (i.e., assembly by comparatively heavy hammer blows in the extreme case). It is used for ball race fits.
LT6	H8/m7	Transition fit averaging some slight interference and giving appreciable interference on extreme sizes. It can be used on location fits with forced assembly, in some cases, or for slight interference fits with selective assembly. It is used for ball race fits.
LT7	Not allotted	H hole with n shaft is a true transition fit averaging some interference and giving clearance only on extreme size. (n5 is used as a pressfit with hole H6, see below). It is not likely to be used for dismantable spigots or locating fits, but is more suitable for some press fits, general "Tight" fits, interference fits with selective assembly and ball race fits.

INTERFERENCE FITS

LN1	H6/n5	This is the first interference fit with hole H6, i.e., the fit with the smallest minimum interference. Owing to the fine tolerance quality of hole and shaft, it will be used on precision components to give an interference fit of some delicacy, and is obviously costly to manufacture.
LN2	H7/p6	First interference fit with hole H7, i.e., the fit with the smallest minimum interference. It is the standard true press fit for steel, cast iron or brass parts. It can be normally dismantled and reassembled as the degree of interference is not likely to overstrain the parts. Assembly on normal sized parts is possible with an arbor press or by hammer. The degree of grip is probably insufficient where the housing is in light alloy (or material of equivalent elasticity).
LN3	H6/p5 H7/r6 H8/t7	These fits involve an increasing degree of interference and no general recommendation can be made. A thorough investigation into the degree of grip required and the stresses in the parts which will be involved must be made.

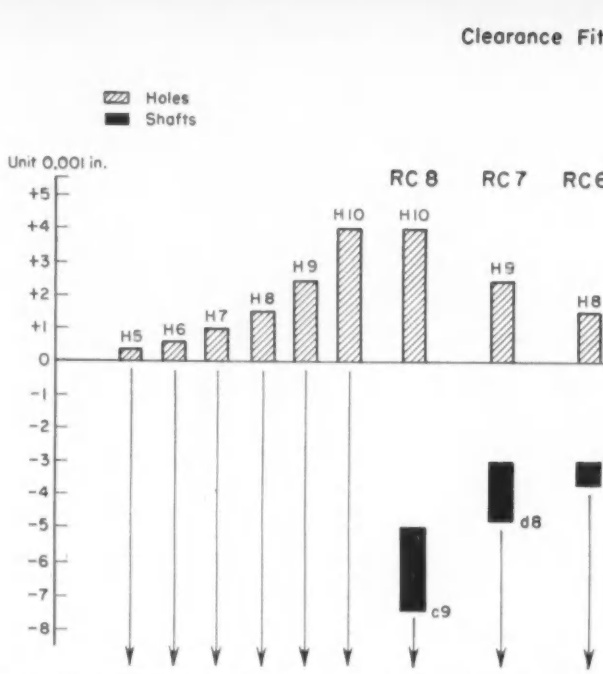
Interference Fits



Diameters over : to (ins.)	Hole H7	Shafts with hole H7											
		p6	fit*	r6	fit*	s6	fit*	t6	fit*	u6	fit*	x7	fit*
.04 – .12	+ .4 + .0	+ .65 + .4	– .65 – .0	+ .75 + .5	– .75 – .1	+ .85 + .6	– .85 – .2	–	–	+ .95 + .7	– .95 – .3	+ 1.3 + .9	– 1.3 – .5
.12 – .24	+ .5 + .0	+ .8 + .5	– .8 – .0	+ .9 + .6	– .9 – .1	+ 1.0 + .7	– 1.0 – .2	–	–	+ 1.2 + .9	– 1.2 – .4	+ 1.7 + 1.2	– 1.7 – .7
.24 – .40	+ .6 + .0	+ 1.0 + .6	– 1.0 – .0	+ 1.2 + .8	– 1.2 – .2	+ 1.4 + 1.0	– 1.4 – .4	–	–	+ 1.6 + 1.2	– 1.6 – .6	+ 2.0 + 1.4	– 2.0 – .8
.40 – .56	+ .7 + .0	+ 1.1 + .7	– 1.1 – .0	+ 1.4 + 1.0	– 1.4 – .3	+ 1.6 + 1.2	– 1.6 – .5	–	–	+ 1.8 + 1.4	– 1.8 – .7	+ 2.3 + 1.6	– 2.3 – .9
.56 – .71												+ 2.6 + 1.8	– 2.5 – 1.1
.71 – .95	+ .8 + .0	+ 1.3 + .8	– 1.3 – .0	+ 1.7 + 1.2	– 1.7 – .4	+ 1.9 + 1.4	– 1.9 – .6	– + 2.1	– – 2.1	+ 2.1 + 1.6 + 2.3	– 2.1 – .8 – 2.3	+ 3.0 + 2.2 + 3.3	– 3.0 – 1.4 – 3.3
.95 – 1.19								+ 1.6	– .8	+ 1.8	– 1.0	+ 2.5	– 1.7
1.19 – 1.58	+ 1.0 + .0	+ 1.6 + 1.0	– 1.6 – .0	+ 2.0 + 1.4	– 2.0 – .4	+ 2.4 + 1.8	– 2.4 – .8	+ 2.4 + 1.8 + 2.8	– 2.4 – .8 – 2.8	+ 3.1 + 2.5 + 3.4	– 3.1 – 1.5 – 3.4	+ 4.0 + 3.0 + 5.0	– 4.0 – 2.0 – 5.0
1.58 – 1.97								+ 2.2	– 1.2	+ 2.8	– 1.8	+ 4.0	– 3.0
1.97 – 2.56	+ 1.2 + .0	+ 2.1 + 1.4	– 2.1 – .2	+ 2.3 + 1.6	– 2.3 – .4	+ 2.7 + 2.0 + 2.9	– 2.7 – .8 – 2.9	+ 3.2 + 2.5 + 3.7	– 3.2 – 1.3 – 3.7	+ 4.2 + 3.5 + 4.7	– 4.2 – 2.3 – 4.7	+ 6.2 + 5.0 + 7.2	– 6.2 – 3.8 – 7.2
2.56 – 3.15						+ 2.2	– 1.0	+ 3.0	– 1.8	+ 4.0	– 2.8	+ 6.0	– 4.8
3.15 – 3.94	+ 1.4 + .0	+ 2.5 + 1.6	– 2.5 – .2	+ 2.9 + 2.0	– 2.9 – .6	+ 3.7 + 2.8 + 3.9	– 3.7 – 1.4 – 3.9	+ 4.4 + 3.5 + 4.9	– 4.4 – 2.1 – 4.9	+ 5.9 + 5.0 + 6.9	– 5.9 – 3.6 – 6.9	+ 8.4 + 7.0 + 9.4	– 8.4 – 5.6 – 9.4
3.94 – 4.73						+ 3.0	– 1.6	+ 4.0	– 2.6	+ 6.0	– 4.6	+ 8.0	– 6.6
4.73 – 5.52	+ 1.6 + .0	+ 2.8 + 1.8	– 2.8 – .2	+ 3.5 + 2.5	– 3.5 – .9	+ 4.5 + 3.5	– 4.5 – 1.9	+ 6.0 + 5.0	– 6.0 – 3.4	+ 8.0 + 7.0	– 8.0 – 5.4	+ 11.6 + 10.0	– 11.6 – 8.4
5.52 – 6.3						+ 5.0 + 4.0	– 5.0 – 2.4	+ 6.0 + 5.0	– 6.0 – 3.4	+ 8.0 + 7.0	– 8.0 – 5.4	+ 13.6 + 12.0	– 13.6 – 10.4
6.3 – 7.09						+ 5.5 + 4.5	– 5.5 – 2.9	+ 7.0 + 6.0	– 7.0 – 4.4	+ 9.0 + 8.0	– 9.0 – 6.4	+ 13.6 + 12.0	– 13.6 – 10.4
7.09 – 7.88	+ 1.8 + .0	+ 3.2 + 2.0	– 3.2 – .2	+ 4.2 + 3.0	– 4.2 – 1.2	+ 6.2 + 5.0	– 6.2 – 3.2	+ 8.2 + 7.0	– 8.2 – 5.2	+ 10.2 + 9.0	– 10.2 – 7.2	+ 15.8 + 14.0	– 15.8 – 12.2
7.88 – 8.86						+ 6.2 + 5.0	– 6.2 – 3.2	+ 8.2 + 7.0	– 8.2 – 6.2	+ 11.2 + 10.0	– 11.2 – 8.2	+ 17.8 + 16.0	– 17.8 – 14.2
8.86 – 9.85						+ 7.2 + 6.0	– 7.2 – 4.2	+ 9.2 + 8.0	– 9.2 – 6.2	+ 13.2 + 12.0	– 13.2 – 10.2	+ 17.8 + 16.0	– 17.8 – 14.2
9.85 – 11.03	+ 2.0 + .0	+ 3.4 + 2.2	– 3.4 – .2	+ 4.7 + 3.5	– 4.7 – 1.5	+ 7.2 + 6.0	– 7.2 – 4.0	+ 10.2 + 9.0	– 10.2 – 7.2	+ 13.2 + 12.0	– 13.2 – 10.0	+ 20.0 + 18.0	– 20.0 – 16.0
11.03 – 12.41						+ 8.2 + 7.0	– 8.2 – 5.0	+ 10.2 + 9.0	– 10.2 – 7.0	+ 15.2 + 14.0	– 15.2 – 12.0	+ 22.0 + 20.0	– 22.0 – 18.0
12.41 – 13.98	+ 2.2 + .0	+ 3.9 + 2.5	– 3.9 – .3	+ 5.9 + 4.5	– 5.9 – 2.3	+ 8.4 + 7.0	– 8.4 – 4.8	+ 11.4 + 10.0	– 11.4 – 7.8	+ 17.4 + 16.0	– 17.4 – 13.8	+ 24.2 + 22.0	– 24.2 – 19.8
13.98 – 15.75						+ 9.4 + 8.0	– 9.4 – 5.8	+ 13.4 + 12.0	– 13.4 – 9.8	+ 19.4 + 18.0	– 19.4 – 15.8	+ 27.2 + 25.0	– 27.2 – 22.8
15.75 – 17.72	+ 2.5 + .0	+ 4.4 + 2.8	– 4.4 – .3	+ 6.6 + 5.0	– 6.6 – 2.5	+ 10.6 + 9.0	– 10.6 – 6.5	+ 13.6 + 12.0	– 13.6 – 9.5	+ 21.6 + 20.0	– 21.6 – 17.5	+ 30.5 + 28.0	– 30.5 – 25.5
17.72 – 19.69						+ 11.6 + 10.0	– 11.6 – 7.5	+ 15.6 + 14.0	– 15.6 – 11.5	+ 23.6 + 22.0	– 23.6 – 19.5	+ 32.5 + 30.0	– 32.5 – 27.5

* The fit is the maximum and minimum difference in size of hole and shaft, + denoting clearance and – interference

Clearance Fit



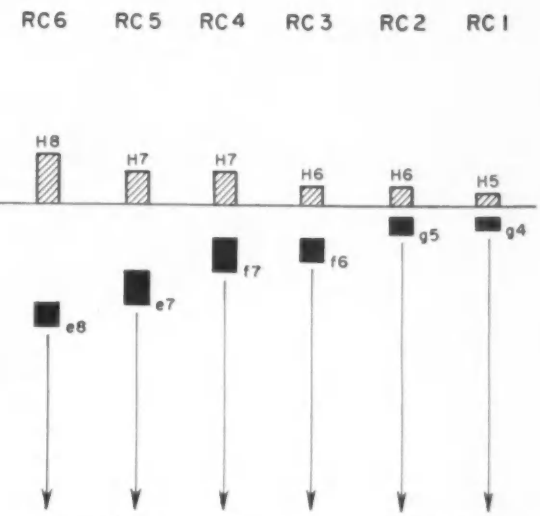
Diameters over : to (ins)	Holes						With hole H10		With hole H9		With hole H8	
	H5	H6	H7	H8	H9	H10	c9	fit*	d8	fit*	e8	f
.04 – .12	+ .2 + .0	+ .25 + .0	+ .4 + .0	+ .6 + .0	+ 1.0 + .0	+ 1.6 + .0	– 2.5 – 3.5	+ 2.5 + 5.1	– 1.0 – 1.6	+ 1.0 + 2.6	– .6 – 1.2	+
.12 – .24	+ .2 + .0	+ .3 + .0	+ .5 + .0	+ .7 + .0	+ 1.2 + .0	+ 1.8 + .0	– 2.8 – 4.0	+ 2.8 + 5.8	– 1.2 – 1.9	+ 1.2 + 3.1	– .8 – 1.5	+
.24 – .40	+ .25 + .0	+ .4 + .0	+ .6 + .0	+ .9 + .0	+ 1.4 + .0	+ 2.2 + .0	– 3.0 – 4.4	+ 3.0 + 6.6	– 1.6 – 2.5	+ 1.6 + 3.9	– 1.0 – 1.9	+
.40 – .71	+ .3 + .0	+ .4 + .0	+ .7 + .0	+ 1.0 + .0	+ 1.6 + .0	+ 2.8 + .0	– 3.5 – 5.1	+ 3.5 + 7.9	– 2.0 – 3.0	+ 2.0 + 4.6	– 1.2 – 2.2	+
.71 – 1.19	+ .4 + .0	+ .5 + .0	+ .8 + .0	+ 1.2 + .0	+ 2.0 + .0	+ 3.5 + .0	– 4.5 – 6.5	+ 4.5 + 10.0	– 2.5 – 3.7	+ 2.5 + 5.7	– 1.6 – 2.8	+
1.19 – 1.97	+ .4 + .0	+ .6 + .0	+ 1.0 + .0	+ 1.6 + .0	+ 2.5 + .0	+ 4.0 + .0	– 5.0 – 7.5	+ 5.0 + 11.5	– 3.0 – 4.6	+ 3.0 + 7.1	– 2.0 – 3.6	+
1.97 – 3.15	+ .5 + .0	+ .7 + .0	+ 1.2 + .0	+ 1.8 + .0	+ 3.0 + .0	+ 4.5 + .0	– 6.0 – 9.0	+ 6.0 + 13.5	– 4.0 – 5.8	+ 4.0 + 8.8	– 2.5 – 4.3	+
3.15 – 4.73	+ .6 + .0	+ .9 + .0	+ 1.4 + .0	+ 2.2 + .0	+ 3.5 + .0	+ 5.0 + .0	– 7.0 – 10.5	+ 7.0 + 15.5	– 5.0 – 7.2	+ 5.0 + 10.7	– 3.0 – 5.2	+
4.73 – 7.09	+ .7 + .0	+ 1.0 + .0	+ 1.6 + .0	+ 2.5 + .0	+ 4.0 + .0	+ 6.0 + .0	– 8.0 – 12.0	+ 8.0 + 18.0	– 6.0 – 8.5	+ 6.0 + 12.5	– 3.5 – 6.0	+
7.09 – 9.85	+ .8 + .0	+ 1.2 + .0	+ 1.8 + .0	+ 2.8 + .0	+ 4.5 + .0	+ 7.0 + .0	– 10.0 – 14.5	+ 10.0 + 21.5	– 7.0 – 9.8	+ 7.0 + 14.3	– 4.0 – 6.8	+

* The fit is the maximum and minimum difference in size of hol

+ denoting clearance and – interference.

ce Fits

To scale for 1.75 in. dia.
All tolerances in units of 0.001 in.



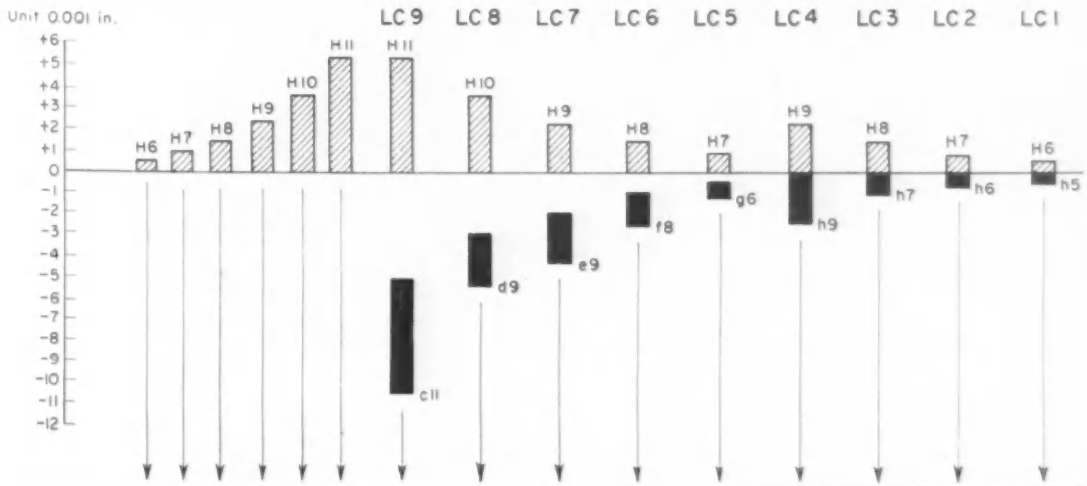
Shafts											
With hole H8		With hole H7		With hole H7		With hole H6		With hole H6		With hole H5	
e8	fit *	e7	fit *	f7	fit *	f6	fit *	g5	fit *	g4	fit *
− .6	+ .6	− .6	+ .6	− .3	+ .3	− .3	+ .3	− .1	+ .1	− .1	+ .1
− 1.2	+ 1.8	− 1.0	+ 1.4	− .7	+ 1.1	− .55	+ .8	− .3	+ .55	− .25	+ .45
− .8	+ .8	− .8	+ .8	− .4	+ .4	− .4	+ .4	− 1.5	+ .15	− .15	+ .15
− 1.5	+ 2.2	− 1.3	+ 1.8	− .9	+ 1.4	− .7	+ 1.0	− .35	+ .65	− .3	+ .5
− 1.0	+ 1.0	− 1.0	+ 1.0	− .5	+ .5	− .5	+ .5	− .2	+ .2	− .2	+ .2
− 1.9	+ 2.8	− 1.6	+ 2.2	− 1.1	+ 1.7	− .9	+ 1.3	− .45	+ .85	− .35	+ .6
− 1.2	+ 1.2	− 1.2	+ 1.2	− .6	+ .6	− .6	+ .6	− .25	+ .25	− .25	+ .25
− 2.2	+ 3.2	− 1.9	+ 2.6	− 1.3	+ 2.0	− 1.0	+ 1.4	− .55	+ .95	− .45	+ .75
− 1.6	+ 1.6	− 1.6	+ 1.6	− .8	+ .8	− .8	+ .8	− .3	+ .3	− .3	+ .3
− 2.8	+ 4.0	− 2.4	+ 3.2	− 1.6	+ 2.4	− 1.3	+ 1.8	− .7	+ 1.2	− .55	+ .95
− 2.0	+ 2.0	− 2.0	+ 2.0	− 1.0	+ 1.0	− 1.0	+ 1.0	− .4	+ .4	− .4	+ .4
− 3.6	+ 5.2	− 3.0	+ 4.0	− 2.0	+ 3.0	− 1.6	+ 2.2	− .8	+ 1.4	− .7	+ 1.1
− 2.5	+ 2.5	− 2.5	+ 2.5	− 1.2	+ 1.2	− 1.2	+ 1.2	− .4	+ .4	− .4	+ .4
− 4.3	+ 6.1	− 3.7	+ 4.9	− 2.4	+ 3.6	− 1.9	+ 2.6	− .9	+ 1.6	− .7	+ 1.2
− 3.0	+ 3.0	− 3.0	+ 3.0	− 1.4	+ 1.4	− 1.4	+ 1.4	− .5	+ .5	− .5	+ .5
− 5.2	+ 7.4	− 4.4	+ 5.8	− 2.8	+ 4.2	− 2.5	+ 3.2	− 1.1	+ 2.0	− .9	+ 1.5
− 3.5	+ 3.5	− 3.5	+ 3.5	− 1.6	+ 1.6	− 1.6	+ 1.6	− .6	+ .6	− .6	+ .6
− 6.0	+ 8.5	− 5.1	+ 6.7	− 3.2	+ 4.8	− 2.6	+ 3.6	− 1.3	+ 2.3	− 1.1	+ 1.8
− 4.0	+ 4.0	− 4.0	+ 4.0	− 2.0	+ 2.0	− 2.0	+ 2.0	− .6	+ .6	− .6	+ .6
− 6.8	+ 9.6	− 5.8	+ 7.6	− 3.8	+ 5.6	− 3.2	+ 4.4	− 1.4	+ 2.6	− 1.2	+ 2.0

e of hole and shaft,

Clearance Fits

Holes
Shafts

To scale for 1.75 in. dia.
All tolerances in units of 0.001 in.

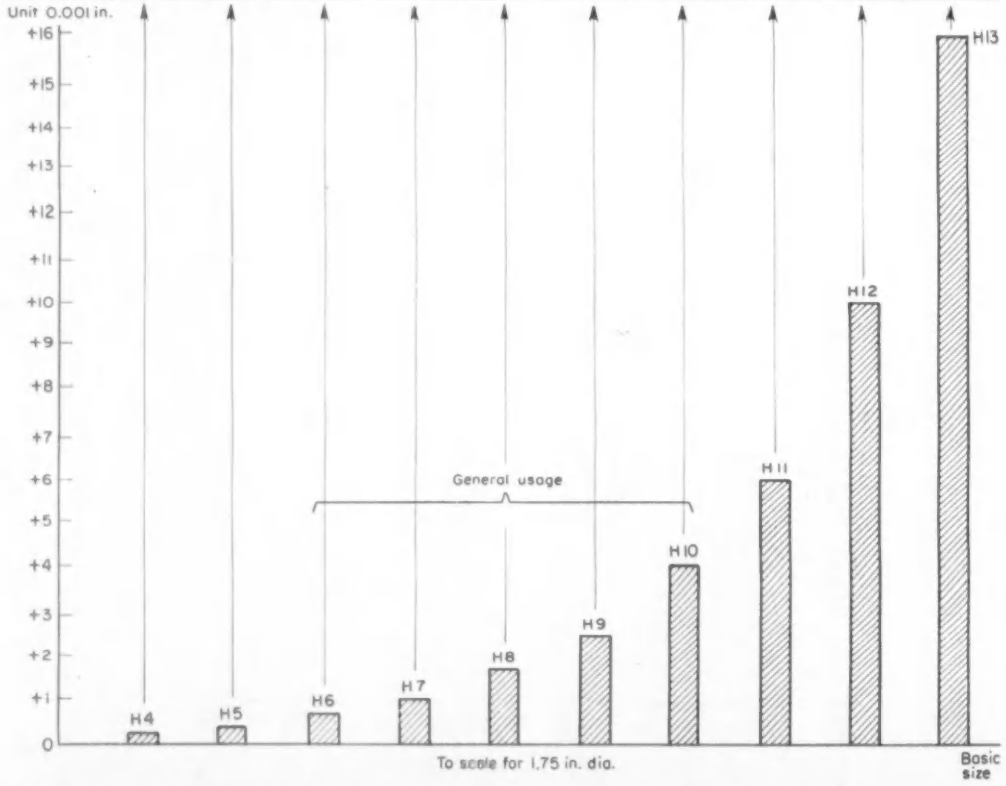


Diameters over : to (ins.)	Holes						Shafts																	
							With hole H11		With hole H10		With hole H9		With hole H8		With hole H7		With hole H9		With hole H8		With hole H7		With hole H6	
	H6	H7	H8	H9	H10	H11	c11	fit *	d9	fit *	e9	fit *	f8	fit *	g6	fit *	h9	fit *	h7	fit *	h6	fit *	h5	fit *
.04 − .12	+ .25	+ .4	+ .6	+ 1.0	+ 1.6	+ 2.5	− 2.5	+ 2.5	− 1.0	+ 1.0	− .6	+ .6	− .3	+ .3	− .1	+ .1	− .0	+ .0	− .0	+ .0	− .0	+ .0	− .0	+ .0
	+ .0	+ .0	+ .0	+ .0	+ .0	+ .0	− 5.0	+ 7.5	− 2.0	+ 3.6	− 1.6	+ 2.8	− .9	+ 1.5	− 3.5	+ .75	− 1.0	+ 2.0	− .4	+ 1.0	− .25	+ .65	− .2	+ .45
.12 − .24	+ .3	+ .5	+ .7	+ 1.2	+ 1.8	+ 3.0	− 2.8	+ 2.8	− 1.2	+ 1.2	− .8	+ .8	− .4	+ .4	− .15	+ .15	− .0	+ .0	− .0	+ .0	− .0	+ .0	− .0	+ .0
	+ .0	+ .0	+ .0	+ .0	+ .0	+ .0	− 5.8	+ 8.8	− 2.4	+ 4.2	− 2.0	+ 3.2	− 1.1	+ 1.8	− .45	+ .95	− 1.2	+ 2.4	− .5	+ 1.2	− .3	+ .8	− .2	+ .5
.24 − .40	+ .4	+ .6	+ .9	+ 1.4	+ 2.2	+ 3.5	− 3.0	− 3.0	− 1.6	+ 1.6	− 1.0	+ 1.0	− .5	+ .5	− .2	+ .2	− .0	+ .0	− .0	+ .0	− .0	+ .0	− .0	+ .0
	+ .0	+ .0	+ .0	+ .0	+ .0	+ .0	− 6.5	+ 10.0	− 3.0	+ 5.2	− 2.4	+ 3.8	− 1.4	+ 2.3	− .6	+ 1.2	− 1.4	+ 2.8	− .6	+ 1.5	− .4	+ 1.0	− .25	+ .65
.40 − .71	+ .4	+ .7	+ 1.0	+ 1.6	+ 2.8	+ 4.0	− 3.5	+ 3.5	− 2.0	+ 2.0	− 1.2	+ 1.2	− .6	+ .6	− 2.5	+ .25	− .0	+ .0	− .0	+ .0	− .0	+ .0	− .0	+ .0
	+ .0	+ .0	+ .0	+ .0	+ .0	+ .0	− 7.5	+ 11.5	− 3.6	+ 6.4	− 2.8	+ 4.4	− 1.6	+ 2.6	− .65	+ 1.35	− 1.8	+ 3.2	− .7	+ 1.7	− .4	+ 1.1	− .3	+ .7
.71 − 1.19	+ .5	+ .8	+ 1.2	+ 2.0	+ 3.5	+ 5.0	− 4.5	+ 4.5	− 2.5	+ 2.5	− 1.6	+ 1.6	− .8	+ .8	− .3	+ .3	− .0	+ .0	− .0	+ .0	− .0	+ .0	− .0	+ .0
	+ .0	+ .0	+ .0	+ .0	+ .0	+ .0	− 9.5	+ 14.5	− 4.5	+ 8.0	− 3.6	+ 5.6	− 2.0	+ 3.2	− .8	+ 1.6	− 2.0	+ 4.0	− .8	+ 2.0	− .5	+ 1.3	− .4	+ .9
1.19 − 1.97	+ .6	+ 1.0	+ 1.6	+ 2.5	+ 4.0	+ 6.0	− 5.0	+ 5.0	− 3.0	+ 3.0	− 2.0	+ 2.0	− 1.0	+ 1.0	− .4	+ .4	− .0	+ .0	− .0	+ .0	− .0	+ .0	− .0	+ .0
	+ .0	+ .0	+ .0	+ .0	+ .0	+ .0	− 11.0	+ 17.0	− 5.5	+ 9.5	− 4.5	+ 7.0	− 2.6	+ 4.2	− 1.0	+ 2.0	− 2.5	+ 5.0	− 1.0	+ 2.6	− .6	+ 1.6	− .4	+ 1.0
1.97 − 3.15	+ .7	+ 1.2	+ 1.8	+ 3.0	+ 4.5	+ 7.0	− 6.0	+ 6.0	− 4.0	+ 4.0	− 2.5	+ 2.5	− 1.2	+ 1.2	− .4	+ .4	− .0	+ .0	− .0	+ .0	− 0	+ .0	− .0	+ .0
	+ .0	+ .0	+ .0	+ .0	+ .0	+ .0	− 13.0	+ 20.0	− 7.0	+ 11.5	− 5.5	+ 8.5	− 3.0	+ 4.8	− 1.1	+ 2.3	− 3.0	+ 6.0	− 1.2	+ 3.0	− .7	+ 1.9	− .5	+ 1.2
3.15 − 4.73	+ .9	+ 1.4	+ 2.2	+ 3.5	+ 5.0	+ 9.0	− 7.0	+ 7.0	− 4.5	+ 4.5	− 3.0	+ 3.0	− 1.4	+ 1.4	− .5	+ .5	− .0	+ .0	− .0	+ .0	− .0	+ .0	− .0	+ .0
	+ .0	+ 0	+ 0	+ 0	+ 0	+ .0	− 16.0	+ 25.0	− 8.0	+ 13.0	− 6.5	+ 10.0	− 3.6	+ 5.8	− 1.4	+ 2.8	− 3.5	+ 7.0	− 1.4	+ 3.6	− .9	+ 2.3	− .6	+ 1.5
4.73 − 7.09	+ 1.0	+ 1.6	+ 2.5	+ 4.0	+ 6.0	+ 10.0	− 8.0	+ 8.0	− 6.0	+ 6.0	− 3.5	+ 3.5	− 1.6	+ 1.6	− .6	+ .6	− .0	+ .0	− .0	+ .0	− .0	+ .0	− .0	+ .0
	+ .0	+ .0	+ .0	+ .0	+ .0	+ .0	− 18.0	+ 28.0	− 10.0	+ 16.0	− 7.5	+ 11.5	− 4.1	+ 6.6	− 1.6	+ 3.2	− 4.0	+ 8.0	− 1.6	+ 4.1	− 1.0	+ 2.6	− .7	+ 1.7
7.09 − 9.85	+ 1.2	+ 1.8	+ 2.8	+ 4.5	+ 7.0	+ 12.0	− 10.0	+ 10.0	− 7.0	+ 7.0	− 4.0	+ 4.0	− 2.0	+ 2.0	− .6	+ .6	− .0	+ .0	− .0	+ .0	− .0	+ .0	− .0	+ .0
	+ .0	+ .0	+ .0	+ .0	+ .0	+ .0	− 22.0	+ 34.0	− 11.5	+ 18.5	− 8.5	+ 13.0	− 4.8	+ 7.6	− 1.8	+ 3.6	− 4.5	+ 9.0	− 1.8	+ 4.6	− 1.2	+ 3.0	− .8	+ 2.0
9.85 − 12.41	+ 1.2	+ 2.0	+ 3.0	+ 5.0	+ 8.0	+ 12.0	− 12.0	+ 12.0	− 7.0	+ 7.0	− 4.5	+ 4.5	− 2.2	+ 2.2	− .7	+ .7	− .0	+ .0	− .0	+ .0	− .0	+ .0	− .0	+ .0
	+ .0	+ .0	+ .0	+ .0	+ .0	+ .0	− 24.0	+ 36.0	− 12.0	+ 20.0	− 9.5	+ 14.5	− 5.2	+ 8.2	− 1.9	+ 3.9	− 5.0	+ 10.0	− 2.0	+ 5.0	− 1.2	+ 3.2	− .9	+ 2.1
12.41 − 15.75	+ 1.4	+ 2.2	+ 3.5	+ 6.0	+ 9.0	+ 14.0	− 14.0	+ 14.0	− 8.0	+ 8.0	− 5.0	+ 5.0	− 2.5	+ 2.5	− .7	+ .7	− .0	+ .0	− .0	+ .0	− .0	+ .0	− .0	+ .0
	+ .0	+ .0	+ .0	+ .0	+ .0	+ .0	− 28.0	+ 42.0	− 14.0	+ 23.0	− 11.0	+ 17.0	− 6.0	+ 9.5	− 2.1	+ 4.3	− 6.0	+ 12.0	− 2.2	+ 5.7	− 1.4	+ 3.6	− 1.0	+ 2.4
15.75 − 19.69	+ 1.6	+ 2.5	+ 4.0	+ 6.0	+ 10.0	+ 16.0	− 16.0	+ 16.0	− 9.0	+ 9.0	− 5.0	+ 5.0	− 2.8	+ 2.8	− .8	+ .8	− .0	+ .0	− .0	+ .0	− .0	+ .0	− .0	+ .0
	+ .0	+ .0	+ .0	+ .0	+ .0	+ .0	− 32.0	+ 48.0	− 15.0	+ 25.0	− 11.0	+ 17.0	− 6.8	+ 10.8	− 2.4	+ 4.9	− 6.0	+ 12.0	− 2.5	+ 5.5	− 1.8	+ 4.1	− 1.0	+ 2.6

* The fit is the maximum and minimum difference in size of hole and shaft, + denoting clearance and − interference.

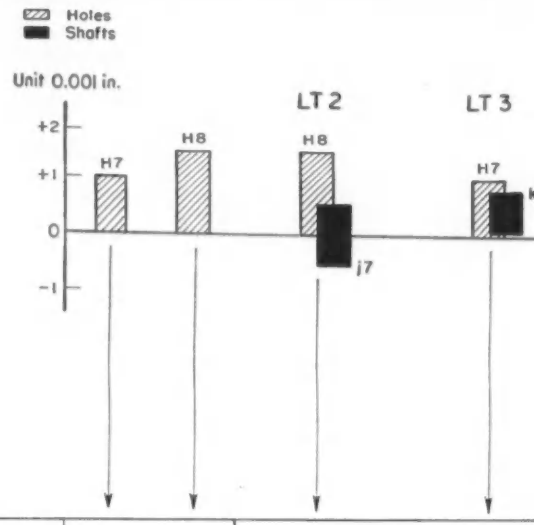
Table of Fundamental Tolerances

Diameters over : to (ins.)	Tolerance grades Tolerance unit 0.001 in.									
	Gr. 4	Gr. 5	Gr. 6	Gr. 7	Gr. 8	Gr. 9	Gr. 10	Gr. 11	Gr. 12	Gr. 13
.04 – .12	.15	.2	.25	.4	.6	1.0	1.6	2.5	4.0	6.0
.12 – .24	.15	.2	.3	.5	.7	1.2	1.8	3.0	5.0	7.0
.24 – .40	.15	.25	.4	.6	.9	1.4	2.2	3.5	6.0	9.0
.40 – .71	.2	.3	.4	.7	1.0	1.6	2.8	4.0	7.0	10.0
.71 – 1.19	.25	.4	.5	.8	1.2	2.0	3.5	5.0	8.0	12.0
1.19 – 1.97	.3	.4	.6	1.0	1.6	2.5	4.0	6.0	10.0	16.0
1.97 – 3.15	.3	.5	.7	1.2	1.8	3.0	4.5	7.0	12.0	18.0
3.15 – 4.73	.4	.6	.9	1.4	2.2	3.5	5.0	9.0	14.0	22.0
4.73 – 7.09	.5	.7	1.0	1.6	2.5	4.0	6.0	10.0	16.0	25.0
7.09 – 9.85	.6	.8	1.2	1.8	2.8	4.5	7.0	12.0	18.0	28.0
9.85 – 12.41	.6	.9	1.2	2.0	3.0	5.0	8.0	12.0	20.0	30.0
12.41 – 15.75	.7	1.0	1.4	2.2	3.5	6.0	9.0	14.0	22.0	35.0
15.75 – 19.69	.8	1.0	1.6	2.5	4.0	6.0	10.0	16.0	25.0	40.0
Holes	H4	H5	H6	H7	H8	H9	H10	H11	H12	H13



Tolerances in the above table are applied directly to give the upper limits of unilateral (H) holes. The lower limit in all cases being the basic size

Transition Fit

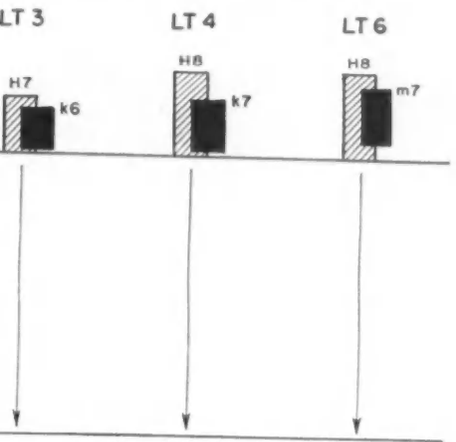


Diameters over : to (ins.)	Holes		With hole H8		With hole H7	
	H7	H8	j7	fit *	k6	fi
.04 – .12	+ .4 + .0	+ .6 + .0	+ .3 – .1	– .3 + .7	–	–
.12 – .24	+ .5 + .0	+ .7 + .0	+ .4 – .1	– .4 + .8	–	–
.24 – .40	+ .6 + .0	+ .9 + .0	+ .4 – .2	– .4 + 1.1	+ .5 + .1	–
.40 – .71	+ .7 + .0	+ 1.0 + .0	+ .5 – .2	– .5 + 1.2	+ .5 + .1	–
.71 – 1.19	+ .8 + .0	+ 1.2 + .0	+ .5 – .3	– .5 + 1.5	+ .6 + .1	–
1.19 – 1.97	+ 1.0 + .0	+ 1.6 + .0	+ .6 – .4	– .6 + 2.0	+ .7 + .1	–
1.97 – 3.15	+ 1.2 + .0	+ 1.8 + .0	+ .7 – .5	– .7 + 2.3	+ .8 + .1	–
3.15 – 4.73	+ 1.4 + .0	+ 2.2 + .0	+ .8 – .6	– .8 + 2.8	+ 1.0 + .1	–
4.73 – 7.09	+ 1.6 + .0	+ 2.5 + .0	+ .9 – .7	– .9 + 3.2	+ 1.1 + .1	–
7.09 – 9.85	+ 1.8 + .0	+ 2.8 + .0	+ 1.0 – .8	– 1.0 + 3.6	+ 1.4 + .2	–
9.85 – 12.41	+ 2.0 + .0	+ 3.0 + .0	+ 1.0 – 1.0	– 1.0 + 4.0	+ 1.4 + .2	–
12.41 – 15.75	+ 2.2 + .0	+ 3.5 + .0	+ 1.2 – 1.0	– 1.2 + 4.5	+ 1.6 + .2	–
15.75 – 19.69	+ 2.5 + .0	+ 4.0 + .0	+ 1.3 – 1.2	– 1.3 + 5.2	+ 1.8 + .2	–

* The fit is the maximum and minimum difference in size of and – interference

on Fits

To scale for 1.75 in. dia.
All tolerances in units of 0.001 in.



Shafts									
th hole H7		With hole H8			With hole H8				
	*			*			*		
	fit	k7		fit	m7		fit		
	−		−	−		+ .55	− .55		
	−		−	−		+ .15	+ .45		
	−		−	−		+ .7	− .7		
	−		−	−		+ .2	+ .5		
− .5	+ .5	+ .7	+ .1	− .7	+ .8	+ .2	− .8	+ .7	
− .5	+ .6	+ .8	+ .1	− .8	+ .9	+ 1.0	+ .3	− 1.0	+ .7
− .6	+ .7	+ .9	+ .1	− .9	+ 1.1	+ .3	− 1.1	+ .9	
− .7	+ .9	+ 1.1	+ .1	− 1.1	+ 1.5	+ 1.4	+ .4	− 1.4	+ 1.2
− .8	+ 1.1	+ 1.3	+ .1	− 1.3	+ 1.7	+ .5	− 1.7	+ 1.3	
− 1.0	+ 1.3	+ 1.5	+ .1	− 1.5	+ 2.1	+ 1.9	+ .5	− 1.9	+ 1.7
− 1.1	+ 1.5	+ 1.7	+ .1	− 1.7	+ 2.4	+ 2.2	+ .6	− 2.2	+ 1.9
− 1.4	+ 1.6	+ 2.0	+ .2	− 2.0	+ 2.6	+ 2.4	+ .6	− 2.4	+ 2.2
− 1.4	+ 1.8	+ 2.2	+ .2	− 2.2	+ 2.8	+ 2.8	+ .8	− 2.8	+ 2.2
− 1.6	+ 2.0	+ 2.4	+ .2	− 2.4	+ 3.3	+ 3.0	+ .8	− 3.0	+ 2.7
− 1.8	+ 2.3	+ 2.7	+ .2	− 2.7	+ 3.8	+ 3.4	+ .9	− 3.4	+ 3.1

e of hole and shaft, + denoting clearance

spond to widening tolerances. The location of the tolerance band relative to the basic size is denoted by a capital letter for holes and a lower case letter for shafts. The location of tolerance bands for the different letter designations are shown in Fig. 2 for the 0.71-1.19 in. basic diameter range of shafts and holes.

In this manner a hole or shaft is completely specified by letter and grade number, and choice of shaft and hole determines the desired fit.

It is evident that a bewildering variety of fits are possible with all the different combinations of shaft and hole tolerances and tolerance band locations. To restrict and standardize the choice somewhat, the "hole" basis has been established in which the series H holes have tolerances which are the basic hole size (zero) at their lower limits. The tolerance band then extends upward above the basic size. The choice of particular tolerance grade and band location for the shaft then determines the fit.

Fits fall into three major categories: clearance, transition and interference. Clearance fits are those in which the shaft is always smaller than the mating hole. Transition fits are those in which the shaft is slightly smaller or larger than the mating hole, depending on the size of each part within its own limits. Interference fits are those in which the shaft is always larger than the mating hole.

American and Canadian preference has been for the assignment of descriptive letter and number symbols to signify the particular mating hole and shaft for a chosen fit. The letter symbols distinguish five classes of fits with the following symbols:

Location Clearance	LC
Running Clearance	RC
Transition Location	LT
Location Interference	LN
Force Interference	FN

Numbers following these letter designations indicate the particular grade of fit within the five classes. The tables included in the gatefold list each fit designation with its corresponding hole and shaft.

Hole Tolerances

Following is a summary of the uses of the various qualities of unilateral hole H from H5 to H11 (or grades 5 to 11):

- H5 Only produced by precision boring or lapping with the finest workmanship.
- H6 Produced by fine grinding or honing, and possibly hand reaming. It is used for precision bearings, bushes, spigots, etc.
- H7 Standard high quality hole produced by grinding, broaching, or high quality turning and careful reaming. It is generally used for high quality work.
- H8 Standard hole produced by all normal accurate machine processes for good quality products.
- H9 Suitable for coarse quality diameter fits only, but is used on high quality products for milled or slotted widths.
- H10 Not normally used for diameter fits, although it can be used for drilled holes. It is used for milled widths of unimportant parts.
- H11 Coarse, drilled, punched or pressed holes on non-fitting parts.

Special Fits

A wide range of special fits which are sometimes used are included in the ABC Standard. Examples of these are found in the use of shaft basis fits, (instead of hole basis), and oversize or undersize holes.

Shaft Basis Fits: There are shops that prefer to retain a shaft basis system for special reasons and the published tables include fits which should satisfy these special requirements. General adoption, however, is discouraged. The most common example of such fits occurs where it is desired to use a standard shaft machined to one size by some simple process, such as grinding, variations in fit being produced by a variety of reamed holes; by this means reamer life can be extended by using worn reamers to produce the smaller size holes.

Oversize and Undersize Holes: There is a definite need even with the normal hole basis system for oversize and undersize holes so that on special occasions two or more fits can be obtained on a standard shaft size. A well known example of this is on the outside diameter fits for ball races, or sliding and fixed pulleys on the same shafting.

Probability

The effect of probability on the practical achievement of fits is of some importance but it is difficult to discuss the subject briefly. When large numbers of parts are being made it is often found that the laws of probability apply and that size distribution is regular (or gaussian), few parts being distributed at extremes of tolerance. However, runs of parts, particularly of medium or small quantities, may occur with "skew" distribution where the greater number of parts in a batch is grouped at one extreme of tolerance (i.e., mainly large, or small). Under these circumstances it is useless to apply any normal quality control theory.

If adequate precautions can be taken to ensure reasonably regular (or "normal") distributions it is possible to widen tolerances without affecting mean fits, and this process has been adopted by certain firms for use on special products.

While the designer is encouraged to study this problem of probability he is advised to be cautious in applying theoretical arguments without verifying the validity of assumptions on which these arguments are based, as regards his particular production equipment.

EDITOR'S NOTE—Tables included with this article have been reproduced from the "Draft Proposal for an ABC System of Limits and Fits" as agreed on by an ABC Conference in New York in February 1953. This proposal is now under consideration by American Standards Association Committee B4 and it is anticipated that their recommendations will be available shortly. Copies of the proposal are available from the American Standards Association, 70 E. 45 St., N. Y. 17, at $.75 each.

A discussion of statistical control of assembly tolerances entitled "How to Evaluate Assembly Tolerances," by R. H. Johnson, appeared in January 1953 on page 179 of *Product Engineering*.

"Factors of Safety in Tolerance Specifications," by Nelson G. Meagley in March 1953, page 155, describes the concept of a factor of safety in assembly tolerances as based on statistical quality control.

Implied Requirements for Drawings

Every drawing shows right angles, chamfers on corners, symmetry about centerline, etc., which are not dimensioned or called out by notes. Generally, the geometrical requirements of a part are interpreted by the production or shop personnel based on their experience and the type and condition of equipment available.

In order to more accurately control these indefinite features, specifications to accompany the drawings can be very helpful. The specification shown below is based on average manufacturing conditions and methods. It will eliminate unnecessary detail work on the drawings and at the same time insure a product of controlled quality.

BERNHARD ROGGE
Evaluation Engineer, U. S. Army Chemical Corp

Implied Requirements

Concentricity, parallelism, straightness, squareness, ovality, etc., which are indicated by the drawing representation may be gaged at the option of the purchaser, and failure to meet the requirements of the gages provided shall be cause of rejection of the part. The usual allowance provided by such gages will be 40 per cent of the basic clearance between mating parts. By basic clearance is meant the difference between the minimum dimensions of the female part and the maximum dimension of the male part.

Squareness tolerance on sheet metal parts when not specified on the drawings shall be as follows: 90 deg stiffener angle; ±5 deg on formed nonmating parts, ±2 deg on mating parts or when attached to other parts, ±½ deg on square corners, flat or formed. Parts made in blanking dies shall be held to a tolerance of ±$\frac{1}{32}$ in. tolerance unless otherwise specified.

Squareness tolerance on machined or cast parts when not specified on the drawing shall be held to ±½ degree.

Forging tolerances and draft angles: 7 deg draft unless otherwise shown and standard tolerance adopted by the Drop Forging Association.

Dimensions about centerline. Where drawing shows a centerline and an over-all dimension only, the distance from centerline to the dimension line shall be one-half of the over-all dimension and its tolerances and within ±0.0005 in. accuracy.

Use of Drawings

The contractor shall work to the dimensions given on the drawings, and in no case shall the drawings be scaled. Should additional dimensions be required, or if the contractor desires an interpretation to clarify any requirement of the drawing, application therefore shall be made to the purchaser. Underlined dimensions indicate that the drawing is not to scale.

Interchangeability of Parts

In addition to meeting all dimensional requirements, all components, all component parts, materials and accessories shall be interchangeable, except those parts which must be finished in place.

Finish of Fabricated Parts

Symbols. When the word "finish" is placed under the material note for a part and is followed by a finish symbol, the entire piece shall have a finish which is no rougher than that indicated by the symbol, unless a line representing a surface of the piece is given a different finish symbol, in which case all surfaces that are not so marked will have no rougher finish than the general finish indicated.

Protective coatings and finishes which will crack, chip, or scale during normal service life or during extremes of atmospheric conditions shall not be used. Where practicable, steel parts shall be cadmium plated in accordance with Federal Specification QQ-P-416, Type II, class B, or zinc-plated in accordance with Federal Specification QQ-Z-325, with supplementary chromic-acid dip. All brass, bronze, or copper-bearing alloys except sliding or running surfaces, shall be cadmium plated, conforming to Federal Specification QQ-F-416, chromium-plated, conforming to Specification MIL-P-6871, zinc-plated, conforming to Specification QQ-Z-325 or tin-plated.

Burrs and Intersecting Surfaces

All burrs on metal and plastic parts shall be removed. Unless otherwise specified, all intersecting surfaces may be rounded as follows:

Fillets—0.01 in. radius, max
Corners—0.02 in. radius, or 0.02 by 45 deg chamfer max

Sharp edges shall be broken as follows:

small pieces	$\frac{64}{64}$ x 45 deg
medium size pieces	$\frac{32}{32}$ x 45 deg
large size pieces	$\frac{16}{16}$ x 45 deg
extra large size pieces	$\frac{8}{8}$ x 45 deg

Threads

Perfect thread shall mean that the thread shall comply with all dimensional requirements of the latest American Standards Association screw thread standards for the full length of thread between the specified limits. Portions of threads removed by counterbores, milled slots, chamfers, and

Table I—Decimal Dimension and Tolerance of Drilled or Punched Holes for Machine Work

The following table lists standard hole diameters and tolerances which could be produced by any method such as drilling, punching, casting, etc. Note that the dimensions are 0.001 in. less than standard drill size to allow for wear on the body of the drill or punch (see MIL-STD-8 for methods of dimensioning holes).

Drill	Decimal	+Tol.	Drill	Decimal	+Tol.	Drill	Decimal	+Tol.	Drill	Decimal	+Tol.	Drill	Decimal	+Tol.
80	0.0130	0.0028	49	0.072	0.005	20	0.160	0.006	J	0.275	0.009	9/16	0.561	0.010
79	0.0140	0.0029	48	0.075	0.005	19	0.165	0.007	K	0.279	0.009	37/64	0.576	0.010
1/64	0.0151	0.0030	5/64	0.077	0.005	18	0.169	0.007	9/32	0.279	0.009	19/32	0.592	0.010
78	0.0155	0.0030	47	0.078	0.005	11/64	0.171	0.007	L	0.288	0.009	39/64	0.607	0.010
77	0.0175	0.0031	46	0.080	0.005	17	0.172	0.007	M	0.293	0.009	5/8	0.623	0.011
76	0.0195	0.0032	45	0.081	0.005	16	0.176	0.007	19/64	0.295	0.009	41/64	0.639	0.011
75	0.0205	0.0032	44	0.085	0.005	15	0.179	0.007	N	0.300	0.009	21/32	0.654	0.011
74	0.0220	0.0033	43	0.088	0.005	14	0.181	0.007	5/16	0.311	0.009	43/64	0.670	0.011
73	0.0235	0.0033	42	0.092	0.006	13	0.184	0.007	O	0.314	0.009	11/16	0.686	0.011
72	0.0245	0.0034	3/32	0.093	0.006	3/16	0.187	0.007	P	0.321	0.009	45/64	0.701	0.011
71	0.0255	0.0034	41	0.095	0.006	12	0.188	0.007	21/64	0.326	0.009	23/32	0.717	0.011
70	0.0275	0.0035	40	0.097	0.006	11	0.190	0.007	Q	0.330	0.009	47/64	0.732	0.011
69	0.0287	0.0035	39	0.099	0.006	10	0.193	0.007	R	0.337	0.009	3/4	0.748	0.011
68	0.0305	0.0036	38	0.101	0.006	9	0.195	0.007	11/32	0.342	0.009	49/64	0.763	0.012
1/32	0.0308	0.0036	37	0.103	0.006	8	0.198	0.007	S	0.346	0.009	25/32	0.778	0.012
67	0.0315	0.0036	36	0.106	0.006	7	0.200	0.007	T	0.356	0.009	51/64	0.794	0.012
66	0.0325	0.0037	7/64	0.108	0.006	13/64	0.202	0.007	23/64	0.357	0.009	13/16	0.810	0.012
65	0.0345	0.0037	35	0.109	0.006	6	0.203	0.007	U	0.366	0.009	53/64	0.825	0.012
64	0.0355	0.0038	34	0.110	0.006	5	0.205	0.007	3/8	0.373	0.009	27/32	0.841	0.012
63	0.0365	0.0038	33	0.112	0.006	4	0.208	0.007	V	0.375	0.009	55/64	0.856	0.013
62	0.0375	0.0038	32	0.115	0.006	3	0.212	0.007	W	0.384	0.009	7/8	0.872	0.013
61	0.0385	0.0038	31	0.119	0.006	7/32	0.218	0.007	25/64	0.389	0.009	57/64	0.888	0.013
60	0.0395	0.0039	1/8	0.124	0.006	2	0.220	0.007	X	0.395	0.009	29/32	0.903	0.013
59	0.040	0.004	30	0.128	0.006	1	0.227	0.007	Y	0.402	0.009	59/64	0.919	0.013
58	0.041	0.004	29	0.135	0.006	A	0.233	0.007	13/32	0.404	0.009	15/16	0.935	0.013
57	0.042	0.005	28	0.139	0.006	15/64	0.233	0.007	Z	0.411	0.009	61/64	0.950	0.013
56	0.045	0.005	9/64	0.140	0.006	B	0.237	0.007	27/64	0.420	0.010	31/32	0.966	0.013
3/64	0.046	0.005	27	0.143	0.006	C	0.241	0.007	7/16	0.436	0.010	63/64	0.981	0.013
55	0.051	0.005	26	0.146	0.006	D	0.245	0.007	29/64	0.451	0.010	1	0.997	0.013
54	0.054	0.005	25	0.149	0.006	1/4, E	0.249	0.007	15/32	0.467	0.010	1 1/8	1.124	0.013
53	0.059	0.005	24	0.151	0.006	F	0.255	0.008	31/64	0.482	0.010	1 1/4	1.249	0.013
1/16	0.062	0.005	23	0.153	0.006	G	0.259	0.008	1/2	0.498	0.010	1 3/8	1.374	0.013
52	0.063	0.005	5/32	0.155	0.006	17/64	0.264	0.008	33/64	0.514	0.010	1 1/2	1.499	0.013
51	0.066	0.005	22	0.156	0.006	H	0.254	0.008	17/32	0.529	0.010	1 3/4	1.749	0.013
50	0.069	0.005	21	0.158	0.006	I	0.270	0.008	35/64	0.545	0.010	2	1.999	0.013

countersinks, may be considered as "perfect threads" if such operations are required.

Implied tolerance for bevels on threaded holes, corner chamfers and similar features of non-critical nature are to be ± 3 deg regardless of the tolerance indicated in the title block.

Drilled or Punched Holes

Tolerances. Where drilled or punched holes are shown on the drawing and are dimensioned only by drill or letter preference or by linear dimension without a stated tolerance, the tolerance shall be H13 as listed in the ABC proposed system of limits and fits. (Page 166.) Alternatively, when so specified by the purchaser, tolerances shown in Table I may serve as a guide.

Drill point. Unless otherwise specified, all holes drilled to a dimensioned depth shall be drilled with a drill having a 118 deg included angle point.

Dimensioning. The depth of a drilled hole shall be dimensioned on the drawing from the theoretical intersection of the conical and cylindrical surfaces, and shall be so gaged.

Eccentricity

When the maximum permissible eccentricity is specified by the drawing as being applicable to two surfaces of a part or assembly, the eccentricity shall not exceed this maximum at any point on either surface.

Concentricity

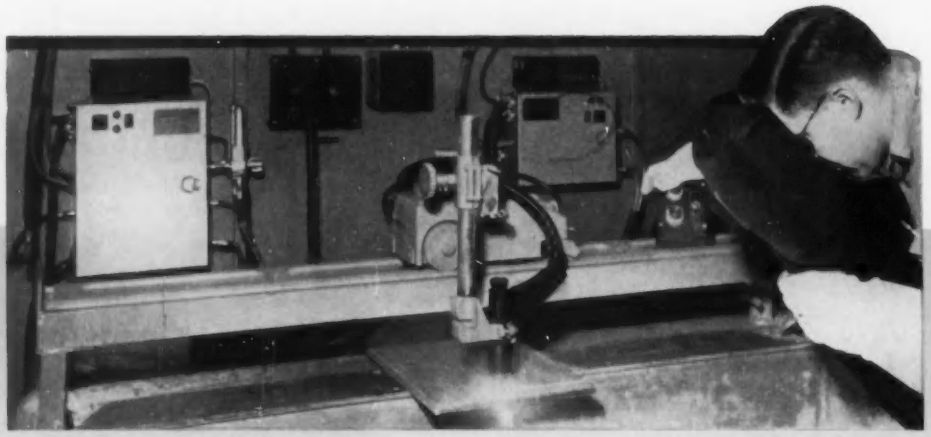
Unless otherwise specified, cylindrical surfaces shall be concentric within a ± 0.001 in. tolerance.

Protective Surface Treatment

Except where otherwise specified, dimensional requirements and tolerances shall apply after plating or other surface treatment prescribed, except that when painting or other organic coating is prescribed the dimensional requirements and tolerances shall apply before application of the coating.

Press Fits

Press fits shall have interferences as given by the LN2 fit designation of the ABC System of Limits and Fits except where otherwise noted. (Page 166.)



NEW TECHNIQUE uses concentrated heat from inert-gas-shielded arc to bring high-conductivity metals to melting point, and a high-velocity gas stream to eject the molten metal. This machine operation on ½ in. aluminum plate can cut at 150 in. per min. with an arc current of 380 amp at 70 volts. Automatic control system provides the high frequency starting arc in an argon atmosphere and initiates the flow of hydrogen when cutting starts; at the end of the cut the arc is automatically extinguished and the gas flow cut off.

Flame Cutting for Nonferrous Metals

Advantages of torch cutting as applied to steel are brought to shaping and cutting nonferrous metals such as aluminum, copper and brass.

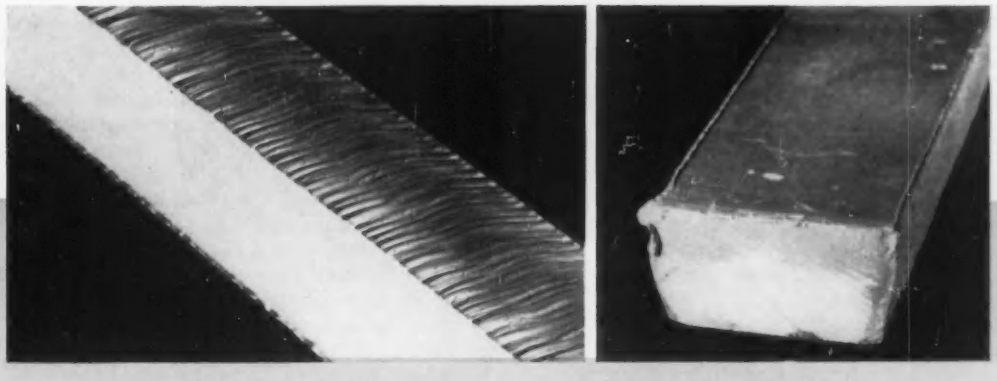
J. W. McCRACKEN
Linde Air Products Co.

IN SHAPING AND CUTTING NONFERROUS METALS, mechanical means—saws, planers and shears—have been the principal method. For steel, flame cutting methods have offered advantages in speed, material handling, flexibility in shape of cut and thickness, and square edges in thick sections. But for nonferrous metals the high thermal conductivity (2 to 8 times that of steel, Table I) dissipates heat too rapidly for practical use of electric arc or oxygen cutting.

The problem of applying flame cutting to nonferrous metals therefore is twofold: provide a concentrated source of high intensity heat to bring the metal rapidly to the melting point, and some means for removing the molten metal leaving a relatively smooth surface. The answer was found in a constricted arc between a tungsten electrode and the work, in conjunction with a high-velocity stream of gas. The columnated energy of the short arc stream melts a film of metal which is swept out by gas pressure, as it melts, leaving a smooth, even surface. The gas atmosphere also prevents oxidation of the kerf walls.

Heliarc cutting, as it is designated, employs the same type of circuit used in Heliarc welding, with a shielding gas consisting of a mixture of argon and hydrogen. The constricted arc is obtained from a water-cooled nozzle or shielding gas cup with an opening ⅛ in. diameter. An auxiliary circuit is provided to initiate the arc: a standard high frequency unit for mechanized cutting, and a pilot arc in an argon atmosphere for manual cutting.

In its current stage of development, the system is ready for use on all aluminum alloys, in thicknesses up to 1 in.,



ALUMINUM PLATE ¼ in. thick machine cut at 70 in. per min. Flame cut surface is quite smooth and uniform; with cutting head held vertical to surface kerf has an angle of about 10 deg.

A 10-IN. CIRCLE, machine cut from ½ in. aluminum plate at 60 in. per min. Cut required 60 cu ft of gas, 65 per cent argon—35 per cent hydrogen.

Table I—Thermal Conductivity

	BTU
Carbon Steel	0.108
Copper	0.81
Aluminum, 2S	0.53
Bronze	0.45
Brass	0.38
Magnesium	0.38
Nickel	0.22
Aluminum, 220	0.21

for manual or machine cutting. Cut edges approach sawing in smoothness. System consists of a cutting head and a control cabinet used in conjunction with a standard electric welding generator, and a supply of gas and cooling water.

Cutting head may be held by hand or mounted on a carriage. Separate lines carry gas and cooling water from the control box. Welding current lead is centered in the cooling water return line, making possible the use of a much smaller flexible lead to handle the heavy currents.

Electrode is ⅛ in. diameter and pointed, set back ¼ in. from the orifice. Maximum currents are 250 amp for ¼ in. orifice and 400 amp for ⅜ in. orifice. Maximum cutting rates for various thicknesses, as given in Table II, compare favorably with rates for oxygen cutting of steel. Amount of argon-hydrogen mixture required increases with thickness and speed, ranging from 30 cfh for light material to 70 cfh for 1 in. thick.

Cutting speed depends primarily on power input; high cutting speeds reduce heat conduction and improve the quality of the kerf. Width of kerf is approximately ⅜ in. at the top and ⅛ in. at the bottom edge.

Major problems faced in developing the new cutting system were: reliable starting, selection of atmosphere, and keeping the power supply within the range of conventional electric arc generators. To make most effective use of the method, an automatic control system was developed which in turn made it possible to produce good quality cuts at high speed.

Two methods of starting are used. In mechanized cutting, a standard high frequency unit is used in conjunction with the pilot circuit to initiate the cutting arc. In manual cutting a pilot arc in an argon atmosphere is used for starting. The pilot circuit was found to be essential for satisfactory starting, but the pilot arc could not be maintained in the argon-hydrogen atmosphere. Also the power of the high-frequency unit had an influence on the reproducibility of starting when long arc lengths were employed. Satisfactory starting was obtained using a standard high-frequency unit and a nozzle-to-work distance of approximately ¼ in. Because the position of the torch in respect to the edge of the plate can be preset in

mechanized cutting, this method of starting is best adapted to machine operation.

Since a pilot arc can be maintained in an argon atmosphere, an alternate method of starting was developed for manual operation. The normal flow of argon was used to maintain the pilot arc and to initiate the main arc. Illumination from the pilot arc helps the operator locate the edge of the plate at the desired point even with his helmet in position. This method of starting is applicable to interrupted cutting in manual operation. When the point of cut is located and the main arc is initiated, the required flow of hydrogen is injected immediately. At the conclusion of the cut, the arc is automatically extinguished, and the argon and hydrogen flow cut off.

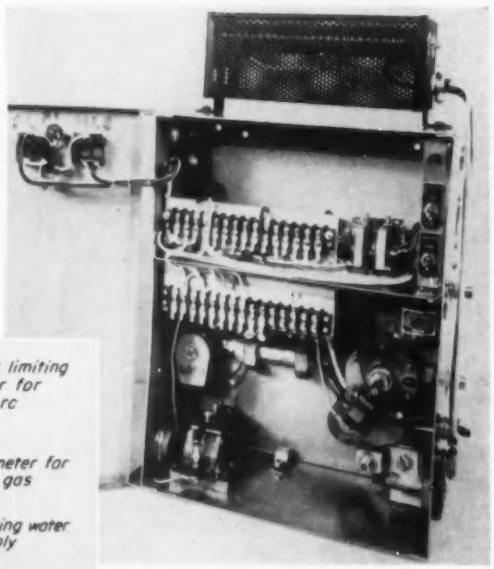
Open-circuit voltage of the power supply is an important factor in ease of starting and maximum arc length in an argon-hydrogen mixture. A relatively high operating voltage is required because of the constricted arc and high resistance atmosphere used for cutting. The operating voltage required depends on the inside diameter of the nozzle, the composition and flow rate of the cutting gas, and the thickness of the plate to be cut. In practice, the arc voltage ranges from 70 to 80 volts. To obtain an adequate current at this voltage level and retain good starting, the power supply must have a high open-circuit voltage.

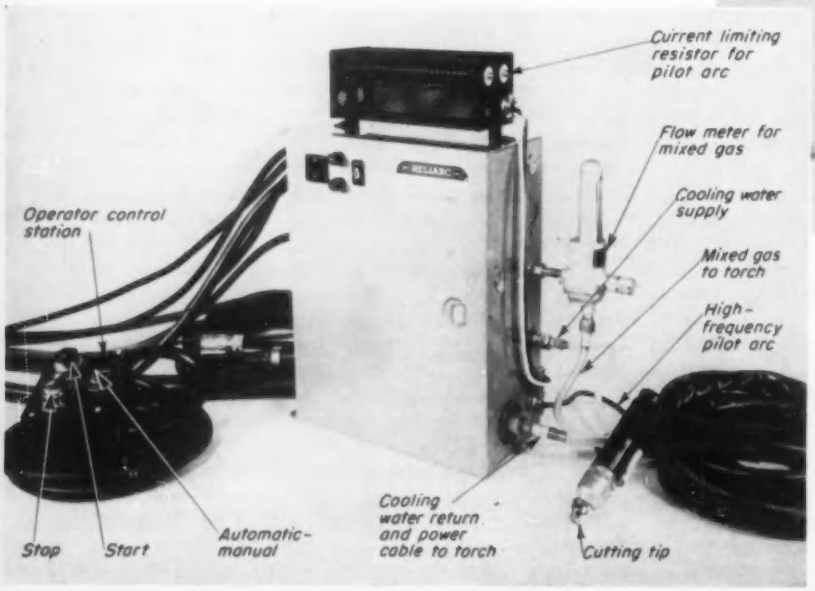
Best results are obtained with a mixture of argon and hydrogen. For machine cutting the optimum mixture is 65 per cent argon and 35 per cent hydrogen. With this mixture a high arc voltage is developed which can be readily obtained with a power supply having an open circuit voltage of 100 volts.

For manual cutting the optimum mixture is approximately 80 per cent argon and 20 per cent hydrogen. The lower hydrogen content is helpful in providing a greater tolerance for variation in arc length. Pure argon is used for initiating and maintaining a pilot arc. As soon as the cutting arc is started, the required mixture is obtained by adding hydrogen to the flowing argon.

Cutting torches employ many of the features of standard welding torches. The manual cutting torch has a 90 deg head and 20 in. long handle. The front head parts, with the exception of the collet and the collet body, are interchangeable between the manual and machine torches. The head is composed of components which permit internal water-cooling of the torch and insulate the metal components of the head from the tungsten electrode. The orifice insert and the retaining nut which holds the orifice insert in place are replaceable. Water-sealing is accomplished by employing an O-ring construction with a metallic gasket being used at the lower end of the unit to withstand the heat of cutting.

Arc current ranges from less than 100 amp to as much as 400 amp. The actual arc voltage may be as high as 70 or 80 volts. Thus, to deliver these voltages at the required amperages, the power supplies must have open-circuit voltages of at least 90 volts, preferably 100 volts. Motor generator sets capable of delivering the required arc voltages are available. These units have an open-circuit voltage of 100 to 110 volts when cold and gradually drift back to 90 or 95 volts when warmed up. A 600 amp gen-





CONTROL EQUIPMENT automatically times starting generator, gas and water flow, and welding current—for either manual or machine cutting. When set for machine cutting, the automatic cycle initiated by monentary contact of the "start" button first operates solenoid valves releasing gas and water flow, and then energizes the high-frequency generator just long enough to start the arc. When cutting arc is established a holding circuit seals in the "start" contact, and the carriage is started. At the end of the cut, lack of a ground extinguishes the arc and the holding circuit is released.

Table II—Comparison of Cutting Rates for Steel (Oxygen Cutting) and Aluminum (Heliarc)

Square-cut thickness, in.	Max Speed Comparison: Oxygen-cutting Steel		Heliarc-cutting Aluminum	
	Mechanized	Manual	Mechanized	Manual
¼	30 in./min.	25 in./min.	300 in./min.	60 in./min.
½	25 in./min	23 in./min.	150 in./min.	40 in./min.
¾	20 in./min.	21 in./min.	75 in./min.	30 in./min.
1	20 in./min.	18 in./min.	50 in./min.	20 in./min.

Table III—Representative Performance in Cutting Aluminum

MANUAL OPERATION,

Thickness In.	Type of Cut	Speed ipm	Flow* cfh	Orifice Dia-In.	Amperes DCSP	Volts
¼	Square	25	50	1/8	100	65
¼	Square	60	50	1/8	200	62
½	Square	40	60	1/8	240	65
¾	Square	30	70	5/32	300	75
1	Square	20	70	5/32	340	75

* 80 per cent argon—20 per cent hydrogen

MACHINE OPERATION,

Thickness In.	Type of Cut	Speed ipm	Flow* cfh	Orifice Dia-In.	Amperes DCSP	Volts
¼	Square	100	50	1/8	200	62
¼	Square	300	70	5/32	350	65
½	Square	75	50	1/8	220	65
½	Square	150	70	5/32	380	70
½	30° Bevel	100	70	5/32	320	72
¾	Square	45	70	5/32	280	75
¾	Square	75	70	5/32	350	75
¾	30° Bevel	35	70	5/32	300	78
1	Square	50	70	5/32	360	78

* 65 per cent argon—35 per cent hydrogen

erator will deliver a maximum of approximately 400 amps at 70 volts. A 400 amp unit will deliver approximately 225 amps at 70 volts. The maximum current output will be increased somewhat when operating at lower than 70 volts arc voltage.

The open-circuit voltage of rectifier-type power supplies is in the order of 70 to 75 volts which is too low to be of use in this application. It is possible to connect two of these units in series in order to obtain an open-circuit voltage of 140 to 150 volts, but an open-circuit voltage this high can be hazardous to operators.

This new cutting system has been used successfully to shape all aluminum alloys, cutting square edges and bevels, preparing plates for welding; stack cut, shape cut, and circle cut operations are practical. The limitation is thickness, at present up to and including 1 in. This new process compares favorably to the ease of making oxygen cuts in identical thicknesses of carbon steels and the results rival sawing the same metal. The speed of operation and plate thickness for metals other than aluminum are primarily dependent upon the melting point and thermal conductivity. Cutting recommendations for other metals and alloys will be offered as soon as current experimental work is completed.

Various types of edge preparation may be obtained by merely tilting the torch. These include single bevels and double bevels with or without a nose. Shape and circle-cutting can be accomplished using the same conditions as listed for straightline cutting. Stack-cutting of sheet and plate up to a total thickness of 1 in. can be satisfactorily done by clamping the sheets together, the same as for conventional stack-cutting. Trimming of an edge, such as removing ⅛ in., can be accomplished without difficulty.

Gouging can be done by employing a leading torch angle of 45 deg, thereby ejecting the molten metal forward.

Any thickness of aluminum that can be cut can likewise be pierced. Therefore, it is not necessary to start the cut at the edge of the plate. If the torch is not moved relative to the plate, a round hole can be pierced.

Manual Cutting Procedure

The control is ready for use as soon as the main-line switch is turned on; no warm-up period is necessary. The power supply should be set and gas flows adjusted. The pilot arc is established by pressing the torch switch. The torch switch opens the water and argon solenoid valves, closes the contactor, and energizes the high-frequency generator. A high-frequency spark is used to start the pilot arc which is then self-maintaining in an argon atmosphere. If the operator releases the torch switch before the cutting arc is established, the pilot arc will be extinguished. This is a fail-safe feature to protect the operator and the torch.

The operator lowers his helmet and locates the starting point of the cut by the illumination provided by the pilot arc. The end of the torch should be about an inch away from the plate at this time. The operator then brings the torch closer to the work. When the orifice is approximately ¼ in. from the workpiece, the main arc will transfer across to the work. As soon as the cutting arc is established, the hydrogen solenoid valve blends a predetermined amount of hydrogen into the gas stream and a holding circuit takes over the control so that the operator may release the torch switch. At the end of the cut the arc will lose its ground and be extinguished. The holding circuit will be de-energized and the control will be ready for the next operation.

Mechanized Cutting Procedure

The torch should be located so that the center of the orifice is approximately ¼-in. above the edge of the plate to be cut. The work should be relatively flat or parallel with the carriage track.

The cutting arc is established by pressing the "start" button. This button energizes the main contactor, the high-frequency generator, and the gas solenoid. The high-frequency generator comes on just long enough to initiate the arc and is then de-energized.

As soon as the cutting arc is established, a holding circuit permits the operator to release the "start" button and the carriage is automatically put in motion. At the end of the cut the arc is extinguished for lack of a ground and the holding circuit is de-energized, the gas solenoid closes and the main contactor opens. The control is then ready for the next operation.

17 Ways of Testing Springs

C. J. McCLINTOCK, CHIEF INSPECTOR, HUNTER SPRING CO.

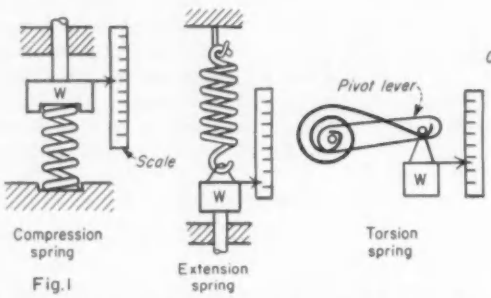
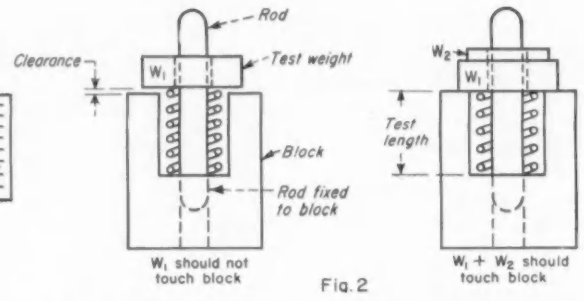


FIG. 1—Dead-weight testing. Weights are directly applied to spring and guided to prevent buckling. Deflections measured with a scale or dial indicator. FIG. 2—Ordnance gage. "Go-no-go" principle used for mass production testing of compression springs. Block is bored for specified test length L. Weight W_1 is slightly less than the minimum specified load at L and therefore should not touch block; W_1 plus load tolerance W_2 must touch block for spring to be acceptable. Lines can be scribed on rod for checking free length of spring.



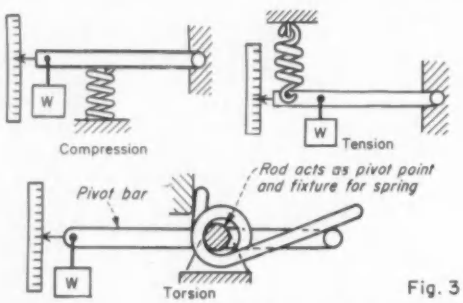
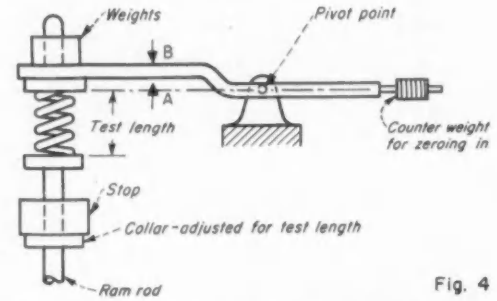


FIG. 3—Pivot-beam testing. More sensitive and with less frictional resistance than guided-gravity testing. Many of the commercial testers based on this principle. FIG. 4—Zero-gradient beam. Uses pivot-beam principle refined for mass production testing. Ram rod is pushed up with pedal or air cylinder. Beam must not touch contacts A or B. Contacting A indicates spring too weak; B indicates spring too strong.



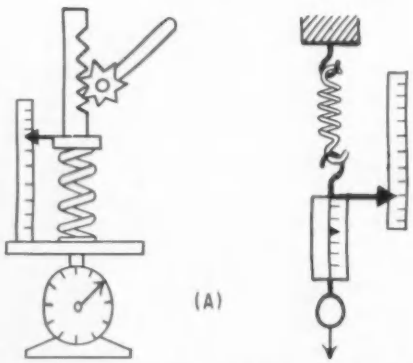
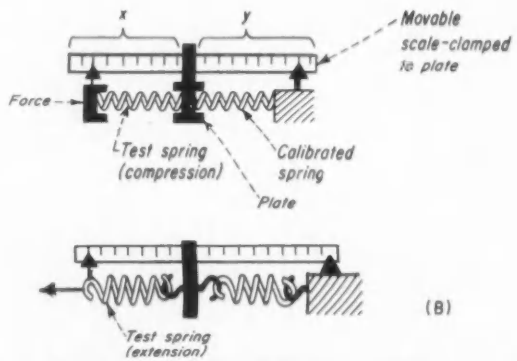


FIG. 5—Spring against spring. (A) Standard spring scales used in place of dead weights for testing short-run springs.



(B) Similar results obtained by using calibrated springs. Section x calibrated for deflection readings; y for load.

Spring dimensions are based on calculations using empirical-theoretical equations. In addition, allowances are made for material and manufacturing tolerances. Thus, the final product may deviate to an important degree from the original design criteria. By testing the springs: (1) Results can be entered on the spring drawing, thus including actual performance data; this leads to more realistic future designs. (2) Performance can be checked before assembling spring in a costly unit.

Shown below are 12 ways, Figs. 1 to 5, to quickly evaluate load-deflection characteristics; for more accurate or fully automatic testing, Figs. 6 and 7, describe 5 types of commercial testers.

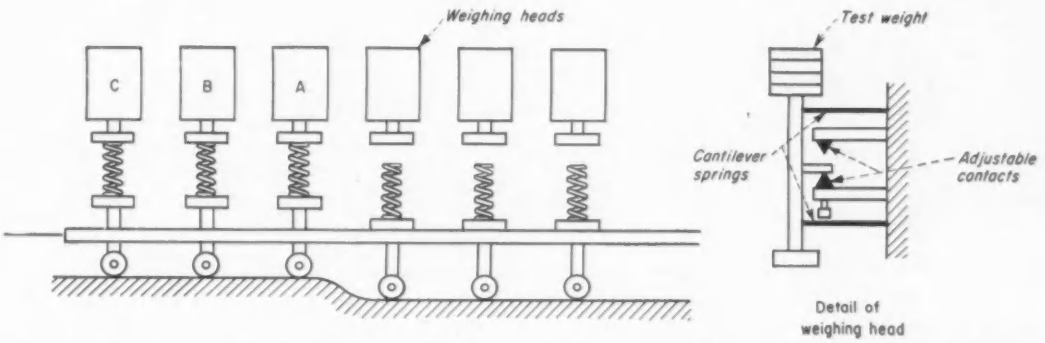
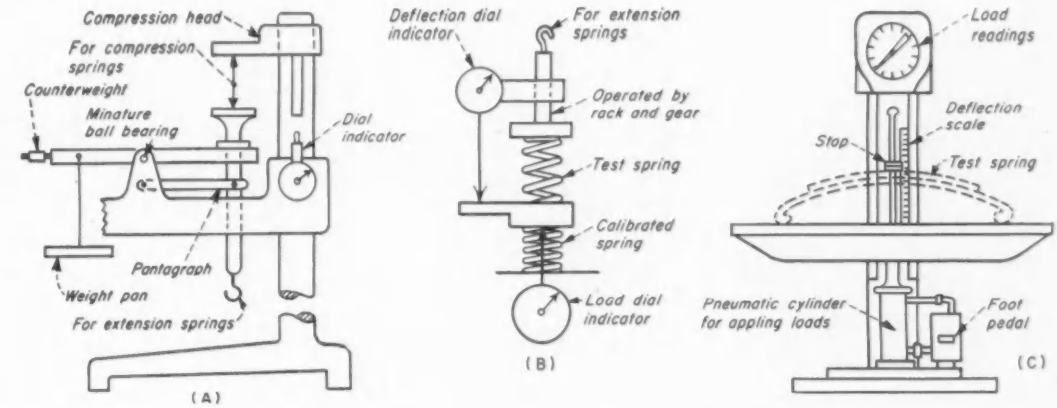


FIG. 6—Fully-automatic testing. Continually moving rotary table with three testing positions. Springs are loaded manually but tested and ejected automatically. Weak springs that allow lower point to make contact are ejected at position *A*; springs too strong ejected at *B*. All springs reaching point *C* are ejected as acceptable.



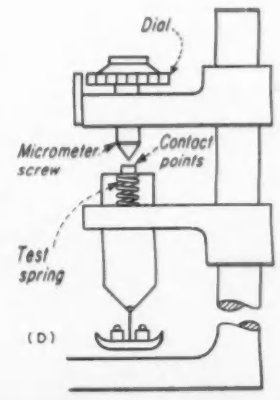
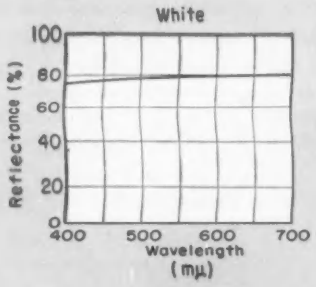


FIG. 7—Commercial testers: (A) Balanced-beam tester uses dead weights for loads. Pantagraph linkage keeps weighing head vertical irrespective of beam movement. Load capacity: 10 lb. *Baldwin-Lima-Hamilton Corp.* (B) Calibrated-spring tester available in several models for testing loads up to 1000 lb. Load applied manually through gear and rack; motor-driven units can be attached for applying heavier loads. *Link Engineering Co.* (C) Pneumatic-operated tester uses torque bar system for applying loads and a differential transformer for accurately measuring displacements. Wide table permits tests on leaf springs. Load capacity: 2000 lb. *Tinius Olsen Testing Machine Co.* (D) Electronic-micrometer tester has sufficient sensitivity (0.0001 in.) to measure drift, hysteresis and creep as well as load deflection. Adjustments made by large micrometer dial; contact indicated by sensitive electronic circuit. Load capacity: 50 lb. *J. W. Dice Co.*

The Measurement of Color and Gloss

Definitions and the derivation of gloss and color scales. Current cans and can'ts of color and gloss instrumentation.



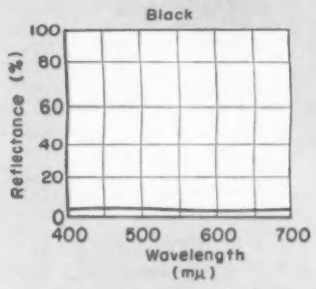


Table I—Numerical Descriptions of Appearance

Are Feasible	Are Not Feasible
IN COLOR IDENTIFICATION	
When a similar standard sample is used to calibrate and check the instrument.	When an exact match is required but no calibrating standards are used.
When only an approximate match is required.	In color matching of geometrically different specimens.
When the geometric observing situation is specified.	Except with relatively poor precision by colorimeters and reflectometers.
When illuminant color is specified.	For the determination of paint or other material ingredients to change color of samples.
To the precision of the eye's ability to distinguish color with careful spectrophotometry and integration of the resulting curve with respect to CIE observer.	
IN SPECULAR GLOSS OR SHININESS	
Where surfaces are semi-gloss or lower.	Where surfaces have high gloss and reflect images.
Where gloss changes are used to measure surface deterioration due to weather, abrasion, etc.	Where additional factors such as reflection, haze, texture, "depth-of-finish," etc., are involved as in polished metals, plated surfaces, and the like.
To locate gloss of specimen on a scale designed for a specific type of material.	For an absolute value of gloss to a specimen since there is no universal scale.

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THE APPEARANCE OF PAINTED SURFACES, enamels, ceramics, paper and similar products depends upon their color, gloss (or luster), surface haze, shape and texture, transparency, and other characteristics, which combine in a complex manner and are almost impossible to define much less accurately measure and specify.

Color is determined by the spectral selectivity of a specimen, as shown in Fig. 1. When illuminated by a white light only the reflected wavelengths are observable and these determine the color appearance.

Gloss is determined by the surface's geometric selectivity in reflecting light. As is demonstrated below in Fig. 8, a rough or mat finish reflects a beam of light diffusely in all directions, whereas a high gloss surface may reflect what appears to be a mirror image of the light source.

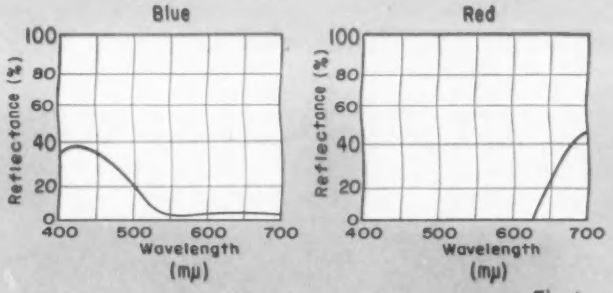


Fig. 1

Fig. 1—Sample spectrophotometric curves of several different colors. It is interesting to note that the curve for the gray, which is perceptually half way between white and black, is actually much closer to the black in per cent reflectance than it is to the white.

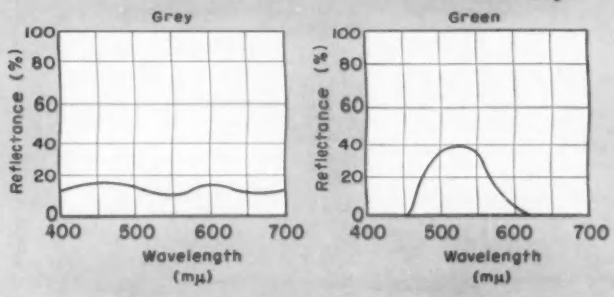
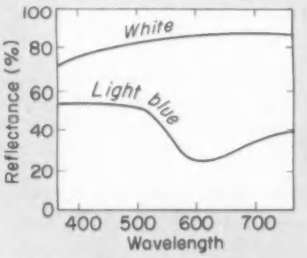
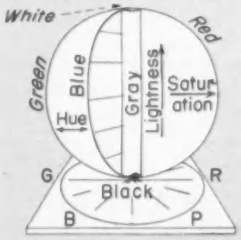


Fig. 2—The different attributes of color may be specified in many different ways dependent upon the measuring instrument.



Spectrophometric curves of percentage of light reflected at each visible wavelength

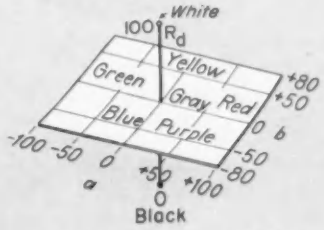


Solid representing colors of surfaces

Hue (direction from axis): red, yellow, green, blue, purple, or intermediate

Lightness: height on scale extending from black to white

Saturation: radius on scale extending from gray axis to periphery representing strongest colors



Dimensions of the Judd-Hunter-Scofield system for surface colors

R_d: reflectance

a : redness–greeness

b : yellowness–blueness

Color difference = $\sqrt{\Delta\sqrt{R_d}^2 + \Delta a^2 + \Delta b^2}$

Fig. 2

A major complication in specifying appearance is the tendency of both color and gloss to change with the incident angles of illumination and view; sometimes gloss even changes with color of illuminant. Since observing situations in everyday experience are infinitely variable in spectral and geometric characteristics, complete specifications of appearance are impossibly cumbersome and complicated.

The human eye can distinguish over four million different shades of color in addition to comparable differences in the other variables, and integrate what is perceived into a recognizable impression within seconds. Present instrumentation can barely match this performance in the measure of color or gloss. The human eye can distinguish two lines as separate if the angle between them is as little as one minute of arc. Current methods of gloss and transparency measurement do not approach this high resolution. Thus, instrument limitations impose restrictions on the

In an effort to relate the scientifically derived spectral curves to sensible color, the Commission Internationale de l'Eclairage (CIE) established three spectrophotometric curves for the response of a standard observer to light of all wavelengths in the visible spectrum, as shown in Fig. 3. These response functions are designated *x*, *y* and *z*, and represent the amount of each of three primary light sources whose mixture provides a visual match to light of the given wavelength.

By the application of the CIE response functions sensible color may be given a numerical designation related to the physicist's spectrophotometric curves. Given a spectrophotometric curve of a specimen, each CIE function multiplies the curve wavelength by wavelength and is then totaled. The three totals which result from this integration are called the tristimulus value of reflectance or transmittance.

$$X = \overline{\Sigma}\, xER$$
$$Y = \overline{\Sigma}\, yER$$
$$Z = \overline{\Sigma}\, zER$$

where R represents spectral reflectance (the given curve) and E is the spectral distribution of the illuminant falling on the specimen. In this manner the spectrophotometric physical curve has been transformed into numerical values corresponding to the visual sensation of color.

Having achieved a scientifically reproducible method of color specification in terms of "psychophysical" variables further transformation of the tristimulus values X, Y and Z are possible.

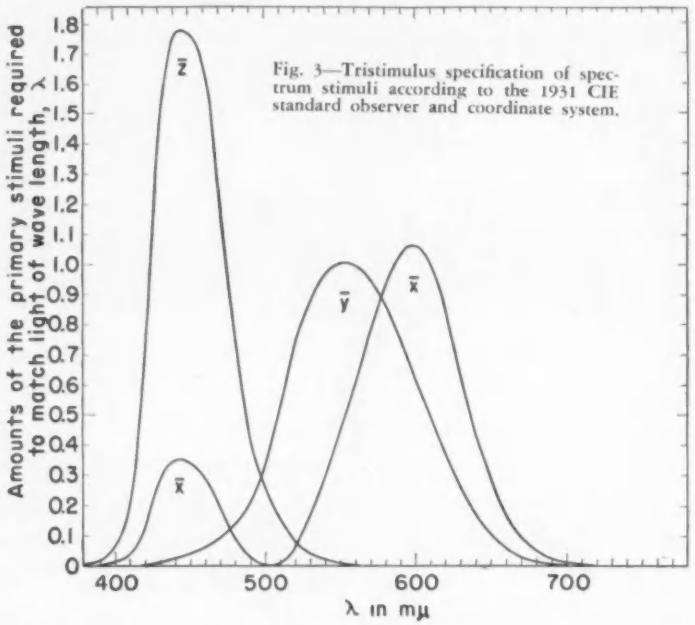


Fig. 3—Tristimulus specification of spectrum stimuli according to the 1931 CIE standard observer and coordinate system.

In one method new variables are defined as follows

$$x = \frac{X}{X + Y + Z}$$

$$y = \frac{Y}{X + Y + Z}$$

$$z = \frac{Z}{X + Y + Z}$$

Because of the nature of this transformation it is evident that

$$x + y + z = 1$$

and the specification of two of the variables predetermines the value of the third. A plot can be made of y versus x which will provide a graphic presentation of color as a function of spectroscopic data. This diagram is a rounded triangle in which white and grays plot near the center and strong colors near the border, as

application of measurements of appearance attributes.

Design engineers unfamiliar with the interaction of appearance attributes would like to think of color, gloss and the others as independent variables which can be separated from interfering factors of structure, composition and environment. Unfortunately, complete separation is impossible. Only by the severe limitation and exact definition of observation conditions is it possible to make practical measurements of appearance attributes. These measurements are now limited to the specification of color and gloss relative to permanent standards, the establishment of production tolerances, and studies of fading and other types of appearance change with use. Table I lists some of the possibilities and limitations of present appearance instrumentation.

Appearance characteristics of materials are most quickly and economically identified by means of standard samples. An inspector compares a new product to the standard samples and accepts or rejects on the basis of subjective judgment. To be successful this method requires a reliable source of supply for the standard samples. Most paints, plastics and textiles of which samples are made are somewhat impermanent in color and gloss, and handling and exposure will change appearance even more rapidly than natural aging.

This method is unsatisfactory since it is dependent upon human judgment and permits no precise numerical specification which can be accurately and repeatably checked.

Available instrumentation is restricted to the consideration of flat, uniformly colored opaque surfaces and films so that shape and texture are removed from consideration. Color can be measured with some degree of precision. Gloss is less amenable to instrumentation, but in limited areas can also be measured with some accuracy.

shown in Fig. 4. This border is the locus of points representing pure spectrum colors. Ellipses have been drawn in different locations about the triangle and they designate the perceptibility of the human eye in different areas. The visual difference between the color of each center dot and its ellipse is perceptibly equal to any other similar distance on any ellipse. It is significant that these ellipses vary in size indicating different degrees of visual sensitivity dependent upon location (color). In this system Y represents the third (luminous) dimension of height above black.

In order to transform the tristimulus values derived above into a more uniform scale of visual perceptibility a further transformation is often made in which

$$L = 10\sqrt{Y}$$

$$a = \frac{1.75\ (1.02\ X - Y)}{\sqrt{Y}}$$

$$b = \frac{0.70\ (Y - 0.847\ Z)}{\sqrt{Y}}$$

Where L is a lightness scale varying from black to white in perceptibly uniform steps. A red-green dimension is measured with the a scale and a yellow-blue dimension by the b scale. On both these scales whites and grays measure near zero. Redness of a specimen is denoted by positive a values, greenness by negative a values. Yellowness is denoted by positive b values, blueness by negative b values.

Except for the rectangular rather than polar coordinates in the horizontal plane, the dimensions of this solid are essentially the same as those of the psychological solids previously described. However, color may here be determined by instruments while those in the psychological solids can only be estimated on the basis of visual comparison. Several other such psychophysical solids are in use today each having been designed around the particular instrument for which they will be used.

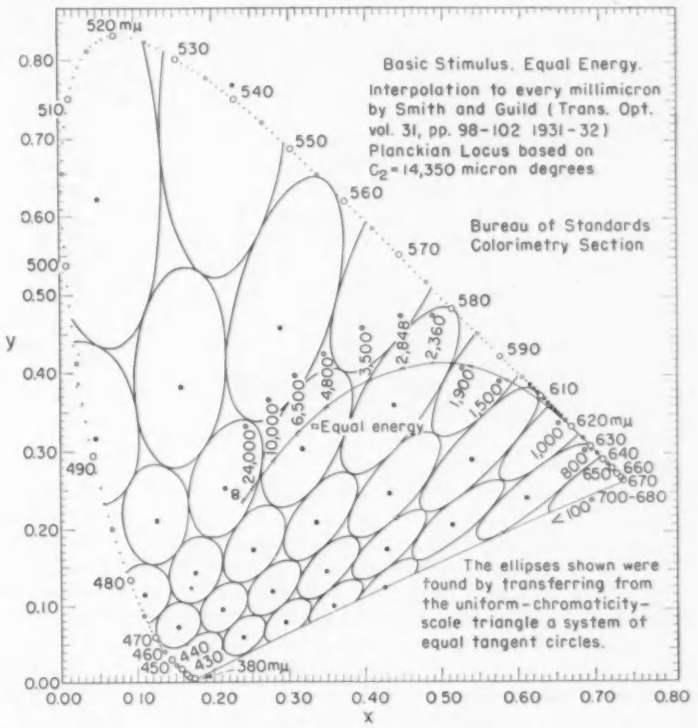


Fig. 4—Mixture diagram based on the discussed mathematical transformation.

COLOR

A physicist defines color with a spectrophotometric curve of per cent reflectance as a function of wavelength throughout the visible spectrum as shown in Fig. 1. The relationship, however, between this curve and the eye's perception of color is extremely complex to all but the optical expert, chiefly because the human eye responds in a highly irregular manner to varying wavelengths of the spectrum.

The physiologist explains that color sensation appears to result from the combined signals of three light receptors in the eye. Variation of the amount of stimulus received by the three receptors alters the subjective sensation of color. The theory is supported by experiments in which any sample color may be matched by a suitable mixture of three primary light sources.

This concept simplifies the specification problem in that it implies that three parameters or dimensions are sufficient to determine any specific color. Mathematical transformation of three independent dimensions permits the use of an infinite number of color scales, each based on a three dimensional frame of reference.

Long before psychologists and physiologists attempted to explain the sensation of color, systematic arrays of color chips or plaques were created and used. A. H. Munsell first published his "Book of Color" in 1905 in which a sphere, as sketched in Fig. 2, is constructed and different points within or on the surface of the sphere represent different colors. Angular position around the sphere determines the hue (red, yellow, green, blue, purple and intermediates). Vertical distance along the axis determines lightness (scale varies from black at the bottom to white at the top). Radial distance out from the axis determines

saturation (from gray at the center to colors of strong, brilliant hue at the periphery). Munsell attempted to space the chips to accord with the visual separation of color throughout the color spectrum.

A second, similar solid was constructed by Ostwald and charts are reproduced by the Container Corporation of America. Here the solid is constructed in the shape of two cones placed bottom to bottom. Saturated colors are spaced around the periphery of the center section. The upper surface is reserved for light clear colors which are mixtures of saturated colors with white. The lower surface is reserved for dark clear colors which are mixtures of saturated colors with black. Many other similar color solids have been constructed and it is significant that most are limited to the three dimensions of hue, lightness and saturation.

One of the chief advantages of the Munsell color charts is that the individual samples vary in a basically regular manner, that is, the perceived color difference between any two adjacent samples is the same regardless of direction or location in the color solid. This characteristic is a great convenience in establishing tolerances widely used in government and industry at the present time. Of course, all color solids are essentially regularized series of standard samples and the disadvantages mentioned above still apply.

The relationship between the spectrophotometric curve and the response of the eye has been established with some accuracy by an international color committee as described in the box above. On the basis of the data so derived, mathematical transformations exist which permit the creation of many three dimensional frames of reference called color scales.

It is a great advantage to have a uniform scale in which perceptible differences between colors are proportional to the differences in scale values. Complete perceptual uniformity in a color scale is probably impossible to achieve because observed differences in color are affected by a number of variable factors in the observing situation, such as the line of division between colors compared and the colors surrounding them. Most uniform color scales designed for use with instrument data are based on the spacing of the Munsell color solid. This is the basis, too, for the widely used scale of color differences derived from uniform color scale values.

It is very difficult to tell from two spectrophotometric curves the magnitude and character of a color difference between two similar specimens. On the other hand, values based on the scales described in the box will readily reveal the magnitude and character of the color difference. By contrast, mathematical values reveal little about the physical causes of color difference between two specimens, whereas spectrophotometric curves will show at what wavelength they are different and thereby suggest the physical basis for the difference.

Formulas for color difference are essentially equations for computing the distance between two points in the Munsell color solid. Color differences are expressed in NBS (National Bureau of Standards) units and may be computed from any of the psychophysical scales mentioned above. Obviously, the more perceptibly uniform the scale, the simpler the computation.

Some tentatively suggested terms for description of color differences in terms of NBS units were made by an Inter-Society Color Council Committee.

	NBS Units
trace	0.0 to 0.5
slight	0.5 to 1.5
noticeable	1.5 to 3.0
appreciable	3 to 6
much	6 to 12
very much	more than 12

In using color-difference measurements four limitations must be kept in mind:

1. Uniform color scales are not perfectly uniform. It is possible for a measurement of 1.0 NBS unit to be visually as large as another of 1.5 or even 2.0 units because of imperfections in the scales or in the instrumentation.

2. Perceptibility and commercial acceptability of differences are frequently not the same. Differences in hue may be intolerable when differences of saturation or lightness of even greater magnitude are acceptable.

3. A single color-difference value will not accurately identify differences under more than one illuminant. As mentioned above, colors are often drastically altered by the type of illuminant and for practical color matching it is desirable to check specimens under at least two illuminants: standard artificial daylight, lamplight, and frequently a third, fluorescent light.

4. A three-number designation of color is not a complete specification of the object's appearance. It does not include luster, gloss, texture and other appearance attributes discernable to the eye, but not the instrument.

Unfortunately, because color scales are based on matching mixtures of light, they cannot be used in any simple way to adjust coloring ingredients in materials. The color of a material is the result of a subtractive mixture of the different coloring constituents used. For this reason, the mixing of pigments, stains and dyes is still considered largely an art.

COLOR INSTRUMENTATION

Types of instruments used for color and color difference measurements are spectrophotometers, tristimulus filter reflectometers and trichromatic colorimeters. Fig. 5 shows the basic elements of all color instruments. All use photoelectric cells to read light intensity.

Spectrophotometers have a prism or a grating to isolate

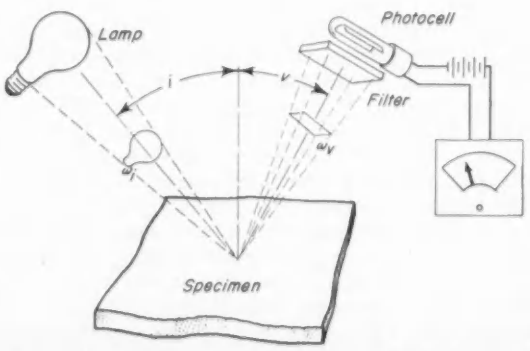
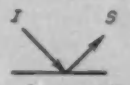
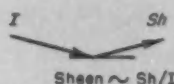
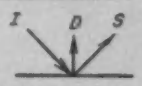


Fig. 5—Elements of a photometric instrument and the quantity it measures.

Table II—Appearance Criteria For Gloss

TYPE OF GLOSS	PERCEPTUAL (Appearance) CRITERION	REFLECTANCE FUNCTION	CLASSES OF SURFACES INVOLVED
Specular gloss	Shininess, brilliance of highlights		Medium gloss surfaces of paint, plastics, etc.
Sheen	Shininess at grazing angles		Low gloss surfaces of paint, paper, etc.
Contrast gloss	Contrast between specularly reflecting areas and other areas		Low gloss surfaces of paint, textile cloth, etc.
Absence-of-bloom gloss	Absence of haze or milky appearance adjacent to reflected highlights		High and semigloss surfaces in which reflected highlights may be seen
Distinctness-of-image gloss	Distinctness and sharpness of mirror images	Not yet measured as function of reflectance	High gloss surfaces in which mirror images may be seen
Surface-uniformity gloss	Surface uniformity, freedom from visible non-uniformities	Not a function of reflectance	Medium to high gloss surfaces of all types

wavelengths of the visible spectrum from 380 to 750 millimicrons. From this information a curve of intensity (or per cent reflectance) may be plotted for the entire visible spectrum. CIE tristimulus values may be determined by a longhand integration process as outlined above or with the GE spectrophotometer and new automatic integrator, color values are integrated automatically.

A filter reflectometer uses at least three filters to replace the prism of the spectrophotometer. These filters do not isolate the narrow bands possible with prisms and gratings, but transmit rather broad spectral bands corresponding to the response functions of the CIE standard observer. Values of per cent reflectance through each of the filters used may be read and substituted, when one is comparing colors of similar specimens, for the tristimulus values which are accurately derived by spectrophotometers and integration.

Colorimeters determine numbers corresponding to the position in a color solid. Tristimulus filters similar to those used in reflectometers are used and simultaneous intercomparisons of the signals from the photocells behind the different filters give numbers correlating directly with observed color.

Careful spectrophotometry and integration of the resulting curves according to the CIE standard observer is the most accurate method of instrumentation. The chief source of inaccuracy in tristimulus instruments is failure of the filter-photocell combinations used to spectrally duplicate the standard functions of the CIE observer. Nevertheless, cost in equipment and time to get readings may frequently call for one of these less accurate methods.

There are geometric as well as spectral distinctions between instruments for reflectance work, commercial instruments use either a diffuse-sphere or a 45 deg geometry. The 45 deg geometry is advantageous because it completely eliminates gloss effects from measured values of color.

None of the color measuring instruments now available is importantly better than the human eye in ability to detect certain small color differences. For the red-green dimension in the L, a, b color solid, mentioned in the box, tristimulus reflectometers and colorimeters must detect signal changes of only 0.03 per cent to equal the best eye in ability to detect color differences.

GLOSS

Gloss is defined as the degree to which a surface simulates a perfect mirror in its capacity to reflect incident light. To the materials engineer gloss is a commercially important attribute of many materials which may be adversely affected during manufacture, storage and use.

As with color, the appearance engineer wants to be able to assign a number which represents a degree of glossiness, as determined by instrument and will correspond roughly to a subjective rating given by an experienced inspector. The designer would like a single instrument and gloss scale to determine gloss, independent of the type of material or industry in which it is used.

Traditionally light reflected from a substantially flat sur-

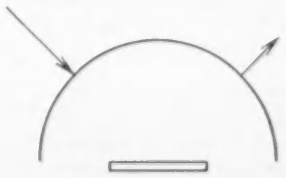


Fig. 6—Traditional rendering of geometric separation of reflected light into specular and diffuse components.

Table III—Established Methods of Gloss Measurements

Angle and Name	Applications	Applicable Specifications	Field Angles, deg (First angle given is in plane of measurement)		Numerical Scale	Important Values	
			Source	Receptor		Polished Black Glass $n = 1.54$	Perfect White (dif. cor. factor)
60 deg ASTM Method D 523	Classify paints, plastics, etc., as high, medium, low, or intermediate in gloss. Measure gloss differences in all gloss ranges but high and very low	ASTM Method D 523-51 T Method 610.1 of Federal Specification TT-P-141b	1 × 4 (maxima)	4.4 × 11.7	G_s perfect mirror = 1000	96	2.5
57½ deg Ingersoll Glarimeter	Measure uncoated white papers for tendency to glare in poor light. Customs test of newsprint	TAPPI T424m-45	12 × 12 (12.6 diameter according to Ingersoll)	Very small	Contrast gloss, polarization method	100	0
75 deg Modified Oxford Method	Gloss of coated, waxes and glassine papers, printed cartons, etc.	TAPPI T480m-51	2.8 × 5.7 (maxima)	11.4 diam	G_s black glass ($n \times 1.54$) = 100	100	1.0
85 deg	Sheen (shininess at grazing angles) of flat matte paints, camouflage coatings, and other surfaces	Method 611.1 of Federal specification	1 × 2	4 × 6	G_s black glass ($n = 1.532$) = 100	100+	0.03
45 deg PEI gloss	Evaluation of acid and abrasion resistance of porcelain enamels	PEI Bulletins T-2 and T-7	1.4 × 3.0	8.0 × 10.0	G_s perfect mirror = 100	5.6	0.53
20 deg High-gloss test	Measure gloss differences of high-gloss enamels and other shiny surfaces (test surfaces must be flat)	Under development	1.0 × 1.8	2.8 × 3.3	G_s black glass ($n = 1.54$) = 100	100	1.8

face may be divided into the part reflected specularly (which is responsible for glossiness) and the part reflected diffusely (which is responsible for color). This geometric distribution of reflected light may be represented by a graph as shown in Fig. 6. Specularly reflected light is represented by a vector in the direction of mirror reflection and diffusely reflected light by a semicircle.

Gloss is responsible for the appearance of highlights on the surface of materials. The brighter the highlights and the more mirror-like the image of the light source, the higher its subjective gloss rating. Measurements of this attribute are made with the goniophotometer from which a curve is derived of directional reflectance as plotted against direction of view. With this instrument reflected light is measured as the source and photocell view directions are varied as shown in Fig. 7. Intensity of reflectance is then plotted in polar coordinates against angle of view and the resultant graph might look like the samples in Fig. 8.

The difference and complexity of goniophotometric curves indicates that gloss is not measurable by one simple gloss scale but is composed of a number of attributes which are subjectively discernable. Some of these attributes are listed in Table II and, as noted in the table, each requires a somewhat different measuring method.

Some presently used methods of gloss measurement are listed in Table III. In the last column, readings are listed which each test method would give for polished black glass and for the ideal, perfectly diffusing white. For more detailed description of these test methods the reader is referred to the specifications listed in the table.

It is evident that no single gloss measuring procedure can ever serve to the needs of materials technology and even now no established procedure exists for some of the attributes.

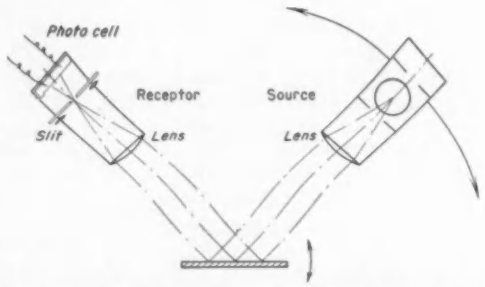


Fig. 7—Diagram of goniophotometer in which plane of specimen and direction of incident light beam may be rotated.

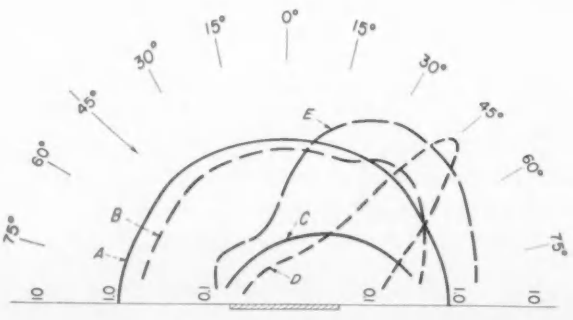


Fig. 8—Goniophotometric curves of five typical surfaces illuminated at 45 deg. (A) White mimeograph paper, (B) white porcelain enamel, (C) low-gloss, olive-drab paint, (D) medium-gloss, olive-drab paint, (E) aluminum paint.

starting methods for three-phase motors

How to protect larger motors (5 hp and up) from undervoltage operation, and at the same time prevent starting voltage dips from affecting operation of other motors.

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Full-voltage starting *for three-phase squirrel-cage motors. Advantages and limitations of selective starting, low-voltage protection, time-delay undervoltage and low-voltage release with automatic starting.*

Reduced-voltage starting *by autotransformer, reactor or resistor controls; part-winding methods and controls for reduced current inrush.*

Wound-rotor motors *and controllers for high starting torque, smooth acceleration and limited starting current.*

ELECTRIC MOTORS ARE DESIGNED to deliver best over-all performance when operated at a specific voltage which is shown on the nameplate. In practice, this voltage is often not maintained; instead, it varies between minimum and maximum limits over what is termed a "voltage spread." This spread is primarily caused by voltage drop in wiring and transformers of the electrical distribution system, and varies in proportion to motor or load currents.

In most modern plants using load-center power distribution systems, variations in voltage normally will be within recommended limits of 4.5 per cent below and 9 per cent above rated voltages for 220, 440 and 550 volt polyphase squirrel-cage and synchronous motors. For motors rated 2300 volts and higher variations allowed are 2 per cent below and 8 per cent above. Table I lists these limits. However, there are many older plants throughout the country with large low-voltage systems. Long low-voltage feeders often cause voltage drops which result in below-standard voltages at the motor terminals, in particular during motor starting when currents may be up to six times normal full-load.

An example of the high current inrush during motor starting is shown in Fig. 1, the full-load, full-voltage starting current of a 200-hp, 440-volt, 3-phase motor. To break away and

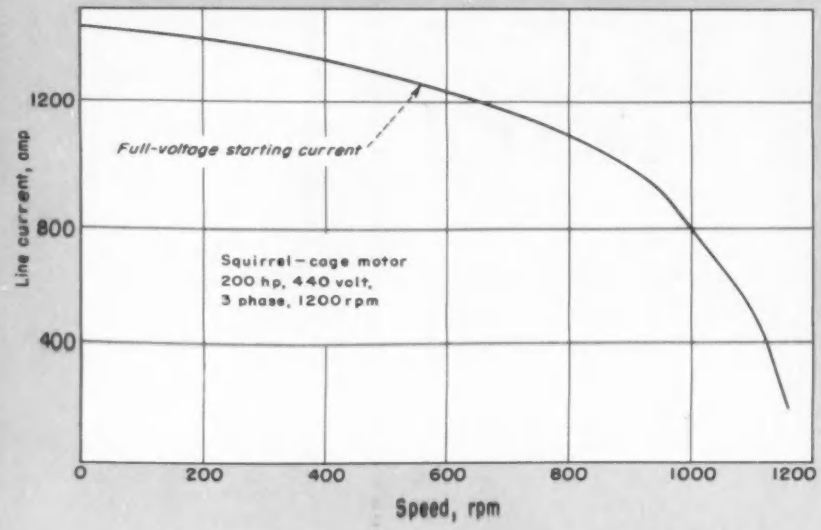


Fig. 1 (Left) – Full-voltage starting of motors produces starting inrush currents of several hundred per cent of full-load current. In rural or underdeveloped areas and in many plants with large low-voltage power systems, these high starting currents produce voltage drops which can damage motor and control equipment not properly selected and applied.

Fig. 2 (Right) – Voltage drops caused by full-voltage starting currents for 10 to 125 hp motors located at varying distances from a power connection can be determined from (A) which shows the drop per hundred amperes for several size conductors of varying lengths, and from (B) which gives the maximum locked-rotor currents for polyphase motors up to 125 hp.

Table I–Recommended Maximum and Minimum Voltages for Polyphase Induction Motors

Rated Voltage	Lower Limit	Upper Limit
220	210	240
440	420	480
550	525	600
2300	2250	2480
4000	3920	4320
4600	4500	5000
6600	6470	7130

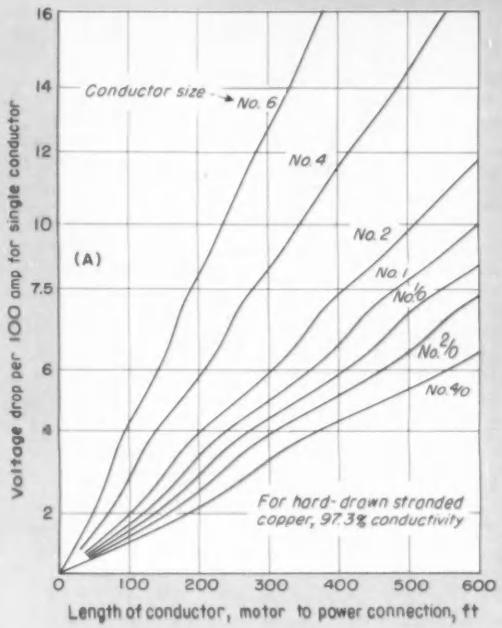
Table II – Effect of Voltage Variations on Performance of Polyphase Induction Motors

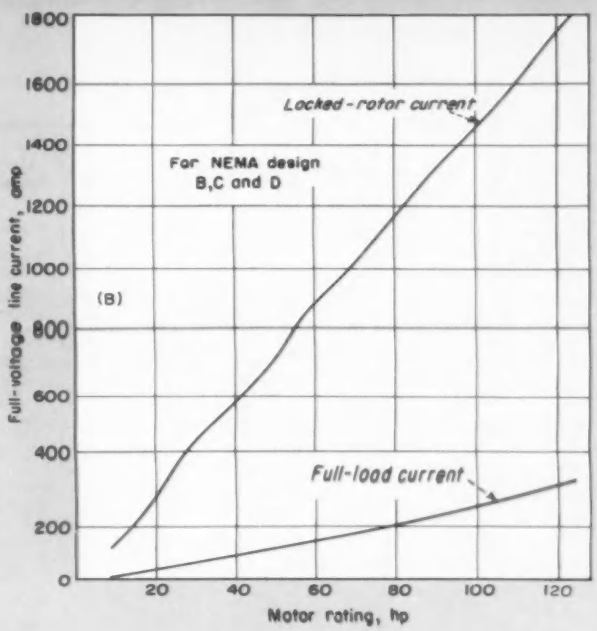
Characteristic	Voltage (in percent of rated)	
	110%	90%
Torque		
Locked-rotor and breakdown	Increase 21%	Decrease 19%
Speed		
Synchronous	No change	No change
Full load	Increase 1%	Decrease 1.5%
Per cent slip	Decrease 17%	Increase 23%
Efficiency		
Full load	Increase 0.5 to 1%	Decrease 2%
¾ load	Little change	Little change
½ load	Decrease 1 to 2%	Increase 1 to 2%
Power-factor		
Full load	Decrease 3%	Increase 1%
¾ load	Decrease 4%	Increase 2 to 3%
½ load	Decrease 5 to 6%	Increase 4 to 5%
Current		
Locked-rotor	Increase 10 to 12%	Decrease 10 to 12%
Full load	Decrease 7%	Increase 11%
Temperature rise	Decrease 3 to 4 C	Increase 6 to 7 C
Maximum overload capacity	Increase 21%	Decrease 19%
Magnetic noise	Slight increase	Slight decrease

accelerate the load takes about 500 per cent of full-load current, diminishing as the motor reaches full-load speed.

Magnitude of voltage drops likely to be encountered can be estimated from curve (A) in Fig. 2, which shows the voltage drop per hundred amperes for lengths of a single conductor between motor and power connection, and from (B), which gives the maximum locked-rotor starting currents for NEMA Design B, C and D motors of 10 to 125 hp when started directly across the line.

Because the current inrush on full-voltage starting is several hundred per cent higher than full load, attempting to start too many motors at the same time, such as the multiple motors driving the transfer-type machine tool shown in Fig. 3, can produce harmful voltage dips at the motors, and also in the system to which they are connected. The minimum operating voltage permitted by motor manufacturers' guarantees is 10 per cent less than rated nameplate voltage. Rated load characteristics of the motors cannot be obtained if the line voltage falls below this point, as is indicated in Table II which shows the effects of voltage variations on NEMA Design B motors. Minimum voltage permitted by the





manufacturer's guarantee for operation of motor controllers is 15 per cent below nameplate rating.

If the voltage dip is of sufficient magnitude or duration it can cause synchronous motors to pull out of step, or release holding circuits in motor starters and stop the motors. On sustained undervoltage motors may be seriously overheated because of the longer accelerating time during which motor winding must carry starting current, and because of higher running currents with motors running at greater percentages of slip. Sustained low line voltage during starting and running is the most common cause of failure in motor-controllers.

A dip in line voltage may not be sufficiently low to allow the starter switch to drop out completely, but may allow it to partially open. Pressure is then lost on the line contacts and severe arcing and burning of the contacts can occur. Operating coils can be burned out because of the increased coil current which flows when the magnetic seal is broken. Such failures are common where the starting of motors

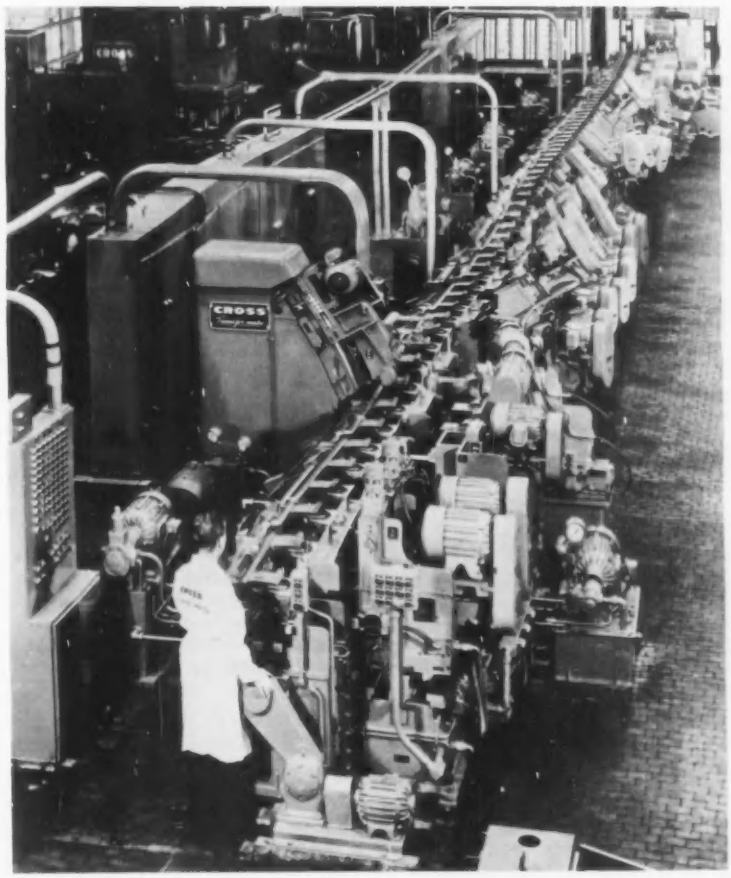


Fig. 3 – In transfer machine tools using a large number of various size motors, simultaneous starting may produce damaging undervoltage unless controllers are properly applied.

causes the line voltage to drop and the voltage slowly builds up as the motor comes up to speed.

Table III – NEC Nameplate Code for Locked-Rotor Starting Current

Code Letter	Kva per Hp	Code Letter	Kva per Hp
A	0 – 3.14	J	7.1 – 7.99
B	3.15 – 3.54	K	8.0 – 8.99
C	3.55 – 3.99	L	9.0 – 9.99
D	4. – 4.49	M	10.0 – 11.19
E	4.5 – 4.99	N	11.2 – 12.49
F	5 – 5.59	P	12.5 – 13.99
G	5.6 – 6.29	R	14.0 and up

For a given rating or motor frame size the locked-rotor current may vary with the design due to allowable variations. Therefore, nameplates on squirrel-cage motors carry a code letter referring to a starting current rating set by the National Electric Code and adopted by NEMA. As shown in Table III, each code letter indicates a specific range of locked-rotor currents in terms of kva per hp. These code letters apply for motors up to 200 hp.

There is no correlation between the NEMA Design letter and the NEC current code letter. Locked-rotor current for NEMA Designs A, B, C, D and F are given in Table IV along with other factors important in the motor starting problem. If the actual value of the motor starting current is not available, an average value of 600 per cent of full-load current is close enough for standard equipment.

All open type Design B, C and D, 3-phase, 220-volt motors have starting currents not in excess of those previously shown in Fig. 2 (B). If the system on which they are to be used has sufficient capacity they may be started with full-voltage controllers. Where starting currents may be too high – because of limited capacity of plant electrical system or power company – application of some type of reduced-voltage starting or a wound-rotor motor may be necessary.

Table IV – Starting Characteristics of NEMA Standard Polyphase Induction Motors

NEMA Design	Sync Speed, Rpm	Hp Range	Torque, per cent of full load		Locked Rotor Current, per cent of full load	Application Characteristics
			Locked-Rotor	Breakdown		
A	3600	1½-200	175-100	Values are in excess of those for Design B		Special high breakdown torque; high locked-rotor current. Slip less than 5 per cent.
	1800	1 -200	275-100			
	1200	¾ -200	175-125			
	200	½ -200	150-125			
	720	½ -200	150-120			
	600	½ -200	115			
	514	½ -200	110			
	450	½ -200	105			
B	3600	1½-200	175-100	275-200		Standard characteristics suitable for most applications; slip under 5 per cent.
	1800	1 -200	275-100	300-200	820-630	
	1200	¾ -200	175-125	275-200	720-622	
	900	½ -200	150-125	250-200	603-591	
	720	½ -200	150-120	200		
	600	½ -200	115	200		
	514	½ -200	110	200		
	450	½ -200	105	200		
C	1800	5 -200	250-200	200-190	820-630	Applications requiring high initial starting torque.
	1200	3 -200	250-200	225-190	720-622	
	900	3 -200	250-200	200-190	603-591	
D	1800	½ -200	275	275	820-630	High torque and slip, 5 per cent or more, for high inertia loads.
	1200	½ -200	275	275	720-622	
	900	½ -200	275	275	603-591	
F	1800	30 -200	125	135		Low locked-rotor current and torque.
	1200	30 -200	125	135		

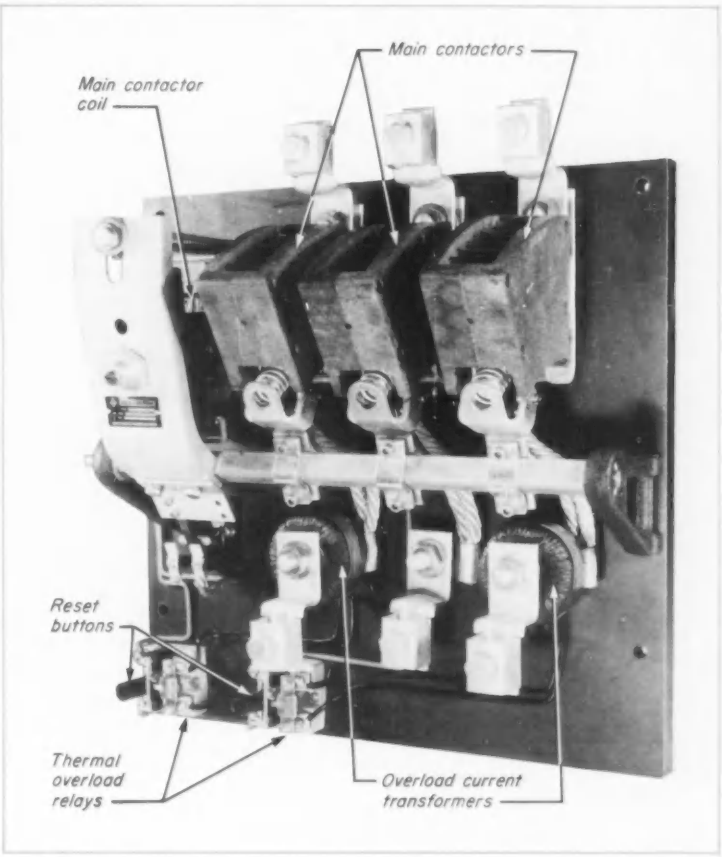
FULL-VOLTAGE STARTING

Full-voltage motor controllers are the least expensive of all starters. There is no limit to the horsepower, size, voltage rating, or type of motor which can be started on full voltage when the power is available. For example, full-voltage starting was used for six 22,500-hp synchronous motors driving pumps (but the installation required a special line from a large hydro-electric generating station).

Full-voltage starters are always first choice when the power system can supply initial inrush current, and the motor and machine can withstand the sudden starting shock. For example, machines which are started unloaded, as well as those that require little starting torque may usually be started at full voltage. Or machines may be equipped with some form of unloading device to reduce starting torque, as in the use of an unloader valve in a compressor. A clutch may be inserted between a machine and motor so the motor may be started unloaded; when the motor is up to speed, the clutch is engaged. Clutches are sometimes used on large machines so that maximum horsepower can be exerted during breakaway without serious power system disturbance. Use of clutches also permits using motors with lower torque and locked-rotor currents.

Standard applications use a full-voltage starter such as shown in Fig. 4, an open type usually designed into the control cabinet of the machine along with the low-voltage control circuits.

Fig. 4 – Size 5, open, 3-phase, full-voltage starter suitable for designing into machine control cabinets. Thermal overload protection is included.



Such contactors have standard NEMA ratings for normal starting applications as listed in Table V. When used for jogging the contactors are derated. A schematic diagram for this type of starter is shown in Fig. 5, which also includes three basic types of control circuits. Most motor controllers are furnished as standard with low-voltage protection and three-wire control from a momentary pushbutton station as shown at (A). Should the line voltage fail or drop severely, this control disconnects the motor from the line.

Selective Starting. If full-voltage starting produces excessive current demands on the distribution system, motors should be started individually or in blocks of permissible size by using some method of time-delay such as motor-driven, pneumatic or mercury plunger timing relays. When large and small motors are to be started on a common power system, best results are obtained by starting largest sizes first; this gives larger motors advantage of full-line capacity. If synchronous motors are on the system with other types of a-c motors, the synchronous units should always be started first since they provide voltage stability for starting the induction motors.

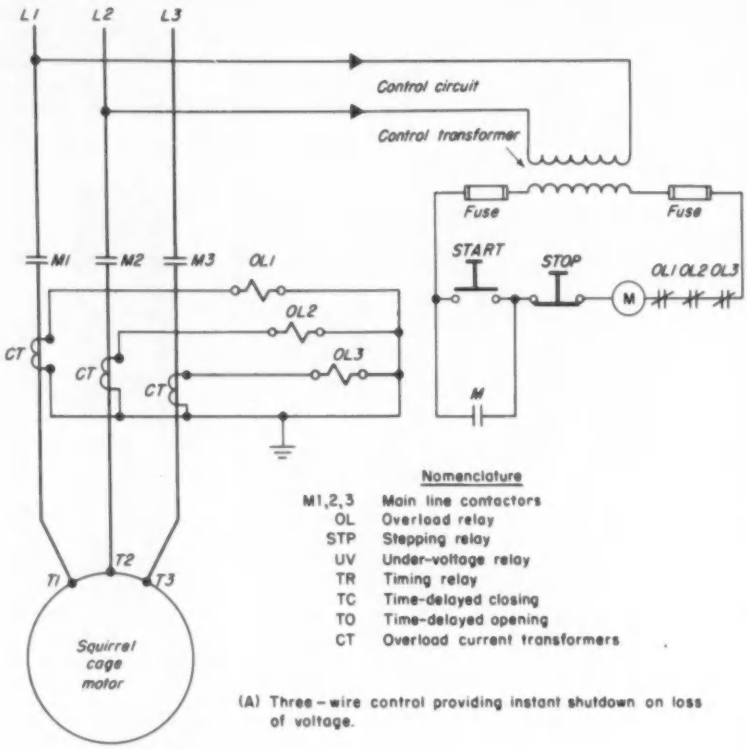
Low-Voltage Protection. Although systematic starting permits all motors to be started without excessive line-voltage drop, the line must still be protected while motors are running. When 3-wire control circuits are used, Fig. 5(A), a severe dip in line voltage or a momentary complete outage breaks the control-sealing circuits, and the controller drops out and stops the motor. This provides "low-voltage protection" and prevents simultaneous acceleration of all motors to full speed after being slowed down by a voltage dip. However, all motors are disconnected from the line during the voltage dip, and each must be restarted.

Time-Delay Undervoltage Protection. In order to overcome this objection, a time-delay undervoltage protection control circuit, shown at (B) in Fig. 5, permits dropout of the controllers on low-voltage dips, but allows restarting automatically if normal voltage is restored within a preset time delay. The usual time delay is 2 sec or less.

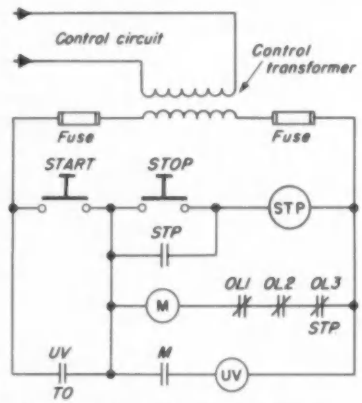
Time-delay undervoltage protection on controllers will prevent some complete shutdowns, but should be applied with caution. If used on all motor controllers, restoration of voltage within the time-delay setting after a voltage dip causes each motor to attempt to accelerate simultaneously, thus producing excessive currents which may

Table V – Comparison of Starting and Jogging Ratings for Three-Phase Magnetic Across-the-Line Starters

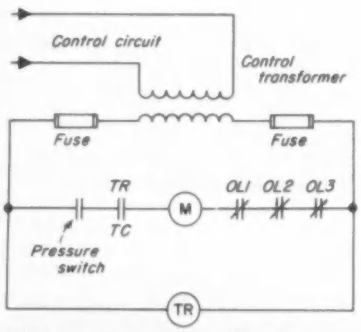
Starter Size No.	8-hr Open Rating of Contactor, Amp	Motor Horsepower at Indicated Voltage					
		Starting			Jogging		
		110	220	440-550	110	220	440-550
00	...	¾	1	1	⅛	½	½
0	15	1½	2	2	¾	1	1
1	25	3	5	7½	2	3	5
2	50	7½	15	25	5	10	15
3	100	15	30	50	10	20	30
4	150	25	50	100	15	30	60
5	300	...	100	200	...	75	150
6	600	...	200	400	...	150	300
7	900	...	300	600	...	200	400



(A) Three-wire control providing instant shutdown on loss of voltage.



(B) Time delay undervoltage provides for automatic restarting during a time interval.



(C) Two-wire control providing low-voltage release and automatic restarting

Fig. 5 – Three types of control circuits for a 3-phase, full-voltage squirrel-cage motor controller. (A) Momentary loss of line voltage removes motor from line and motor will not start until START button is again depressed, thus providing undervoltage protection. (B) This control circuit removes motor from line on severe dip or loss of voltage, but permits motor to restart automatically if voltage is restored within 2 sec. (C) When pilot devices control starting and stopping of motors, this circuit provides a time delay before the motor automatically restarts after severe voltage dip or failure.

operate backup protection and starter overload devices, and disconnect the motors.

Time-delay undervoltage controller combinations offer a compromise solution in which each motor on a system is given priority according to operating importance. High priority motors are equipped with time-delay undervoltage protection with time-delay settings of varying intervals, the most important unit having the longest time setting. Lower priority units have only low-voltage protection, and do not restart automatically. The choice of arrangements depends upon the sizes and types of motors, types of loads, and system capacity, and must be determined for each individual problem. Controllers can also be sequence interlocked, so that upon starting one unit a second motor will be automatically started after a specific time delay.

Low-Voltage Release and Automatic Restarting. Pilot devices such as pressure, float, or temperature switches automatically start and stop motors as the demand requires. On severe voltage dips or voltage failure, motor controllers drop open even though the demand switch is closed. Upon restoration of full voltage all units attempt to restart together. This operating hazard can be overcome by adding a time delay in the starting circuit of each motor, to time after the demand contact has closed. Time delays of various units can then be so staggered that on restoration of voltage only one unit at a time will be started. Such a circuit with time-delay undervoltage protection is shown at (C) in Fig. 5.

Time-delay undervoltage protection should be used only on units where shutdowns on momentary voltage fluctuations cannot be tolerated; these features are available as modifications on high-voltage controllers when absolutely required. Low-voltage systems are generally more subject to frequent voltage fluctuations; to provide the most protection to motor, controller and system, this feature is not standard on low-voltage controllers.

Table VI – General Comparison of Reduced-Voltage Starting Methods

CHARACTERISTIC	AUTOTRANSFORMER	PRIMARY RESISTOR	REACTOR	TWO-STEP PART WINDING
Starting line current at same motor terminal voltage	Least	More than autotransformer type.		
Starting power factor	Low	High	Low	
Power drawn from the line during starting	Low	More than autotransformer type.		
Torque	Increases slightly with speed.	Increases greatly with speed.		Increases slightly with speed
Torque efficiency	Highest starting torque of any reduced-voltage starter for each ampere drawn from the line during the starting period.	Low		
Smoothness of acceleration	Motor momentarily disconnected from line during transfer from **start** to **run.**	Smooth. As motor gains speed current decreases; voltage drop across resistor or reactor decreases and motor-terminal voltage increases. Transfer made with little change in motor terminal voltage.		Motor not disconnected from line on transfer which usually occurs at low speed. Used to provide stepped-current starting
Relative cost	Average	Lower in small sizes, otherwise equal	Average	Less than others
Ease of control	Same			No provision for adjustment of starting current.
Maintenance	Same			Less maintenance than others.
Safety	Same			
Reliability	Same			
Line disturbance	Varies with line conditions and type of load.			More than others.

REDUCED-VOLTAGE STARTING

When a power system or line cannot supply the inrush current required for full-voltage starting, or when the driven machine cannot stand sudden high starting torque, the inrush current and starting torque must be reduced. A principal method is reduced-voltage starting in which steps of resistance or reactance are introduced between the power source and the motor, or the motor is connected to reduced-voltage taps on an autotransformer.

Motors used in rural and other underdeveloped areas usually require reduced voltage starters because of lack of capacity of the power system. When motors are put on lighting circuits or are a considerable distance from incoming plant power lines, starting line disturbances can be serious within the plant. In such applications, reduced-voltage starters may be used on motors as small as 5 hp.

Reduced-voltage starting minimizes the shock of a quick start on a driven machine. This is important where, in a sudden start, gears on large drives may be damaged, belt drives may slip, or large fan blades or couplings and line shafts can be damaged.

A general comparison of autotransformer, primary resistor, primary reactor and two-step part-winding methods of reduced voltage starting is shown above in Table VI.

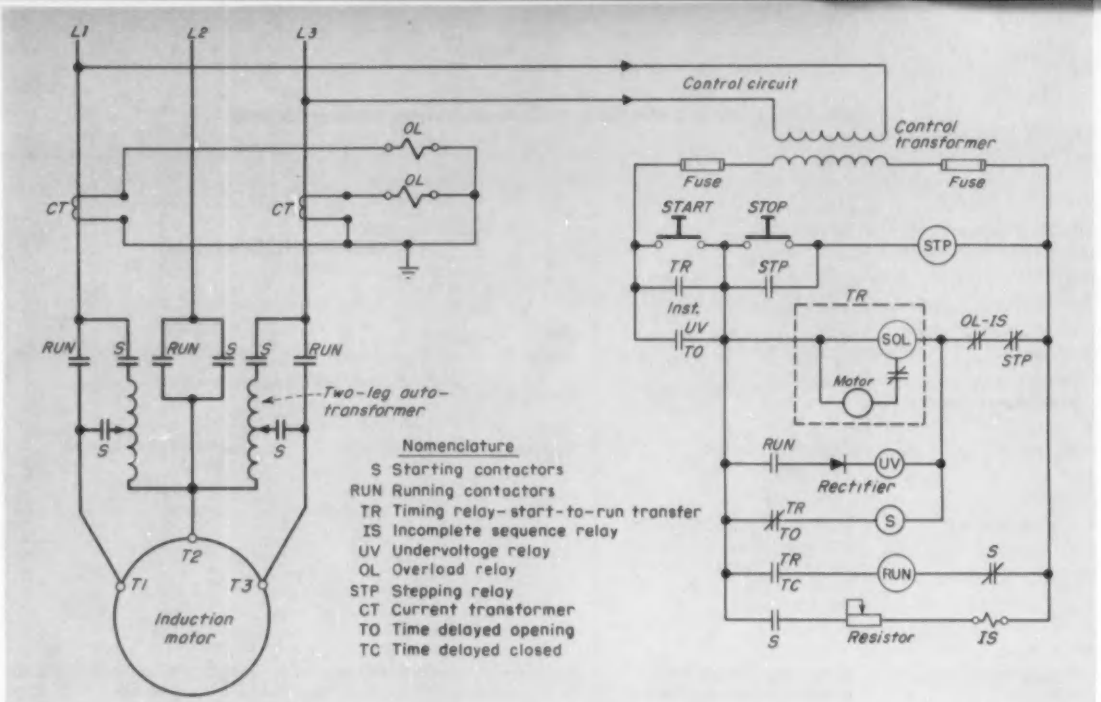


Fig. 6 (Above) – Autotransformer controller; taps are normally available for 50, 60 and 85 per cent of line voltage, but are adjusted for individual application.

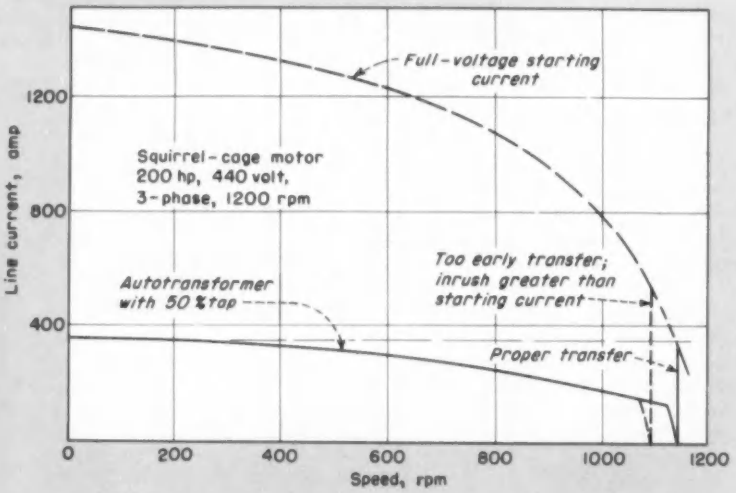


Fig. 7 (Right) – Current drawn for 50 per cent full-voltage autotransformer starting compared to current required for 100 per cent full-voltage starting for a 200 hp, 1200 rpm squirrel-cage motor. Proper transfer from 50 per cent to full voltage occurs at speed at which current does not increase above autotransformer starting current.

Autotransformer Starting

Autotransformer controllers are more commonly used primarily because this type provides the highest starting torque per ampere drawn from line of any reduced-voltage starter. These controllers are available in ratings up to several hundred horsepower for both low and high-voltage motors. Autotransformers are rated for intermittent duty for light, medium or heavy duty applications. Reduced voltage for starting is obtained from taps which are some fraction of the line voltage. The required value of tap voltage is determined by the application, as indicated in Table VII.

Two or three-leg autotransformers are used in 3-phase starters. The two-leg type is least expensive and most commonly used in 3-phase controllers. Fig. 6 shows a typical circuit for a low-voltage, two-leg controller for a squirrel-cage motor. The autotransformer is connected in open delta with a 5-pole starting contactor, a 3-pole running contactor, and the necessary timing and protective relays. In this starter pressing the start button instantly closes the starting contactor, connecting the motor to the reduced-voltage tap on the autotransformer. After a predetermined time which is adjusted to permit proper acceleration of the motor, the timer opens the starting contactor, momentarily disconnecting the motor from the line and then instantly closes **run** contactors which connect motor windings directly to line. Use of the two-leg system produces an unbalance voltage during starting which is 15 per cent higher between

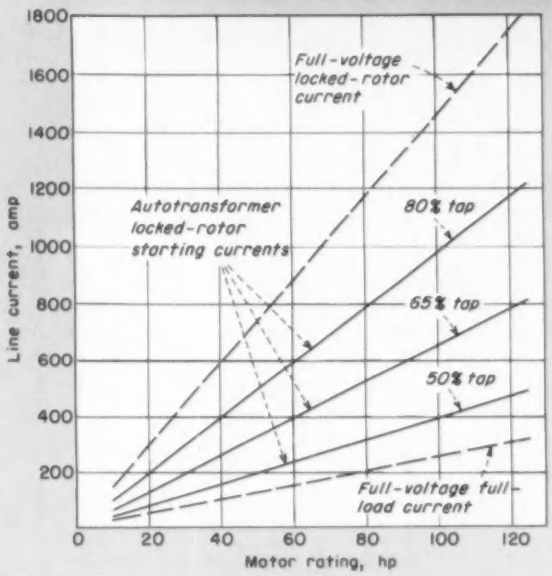
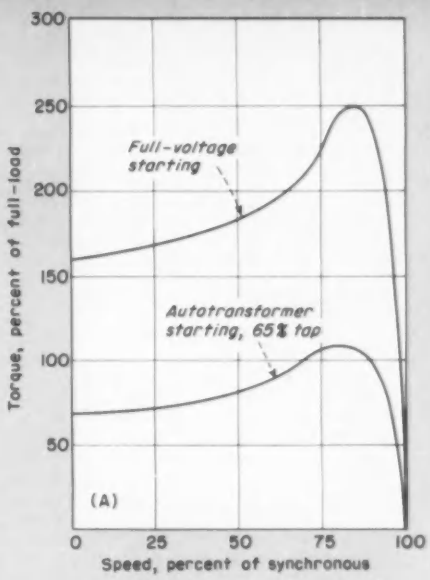


Fig. 8 — Autotransformer starting currents for 50, 65 and 80 per cent voltage taps compared to full voltage currents for 10 to 125 hp, NEMA Design B, C and D motors.



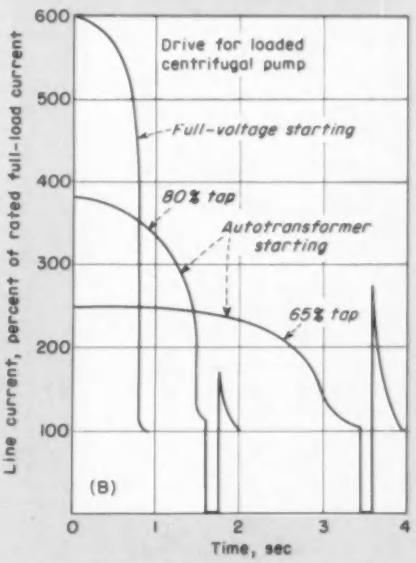


Fig. 9 — (A) Torque-speed characteristics of a squirrel-cage induction motor; full-voltage starting compared to autotransformer starting using 65 per cent of line voltage. (B) Line-current demands and accelerating time required by a squirrel-cage induction motor driving a loaded centrifugal pump; full-voltage starting compared to 65 and 85 per cent voltage autotransformer starting.

Table VII — Autotransformer Voltage Taps

Duty Service	Motor Rating, hp	Starting Taps, per cent of line voltage
Heavy	All	Determined by application
Medium	50 hp and less	65-80
	Above 50 hp	50-65-80
Light	All	30-37.5-45

terminals T2 and T1 or T3 than between T1 and T3. However, except for unusual applications this unbalance is no problem.

Autotransformer starting is "open transition" since the motor is momentarily disconnected from the line during the transfer from starting to running. The main disadvantage is this: when the motor is reconnected at low speeds the transient line disturbance may be severe. A special three-leg transformer circuit providing closed transition starting is available, but is considerably more expensive.

Principal advantage of autotransformer starting is in providing greater starting torque per amp drawn from the line than any other type of reduced-current starting; line current is proportional to the square of the ratio of reduced motor voltage to full line voltage. For example, when the 50 per cent voltage tap is used (assuming no loss in the transformer), starting current is only 25 per cent of the full-voltage locked-rotor current, as shown in Fig. 7. Use of the 80 per cent autotransformer tap draws 64 per cent of full-voltage starting current. These relations are shown in Fig. 8 where starting currents for 10 to 125 hp NEMA Design B, C and D motors using 50, 65 and 80 per cent autotransformer taps are compared to full-voltage starting currents of the same motors. The magnetizing current required by autotransformers is approximately 5 to 10 per cent of the total line current, which should be added if accurate calculations are required.

When starting at reduced voltages, torque is reduced from that obtainable with normal full-voltage starting. The accelerating torque characteristics of a motor using a 65 per cent autotransformer tap are compared to full-voltage starting in (A) of Fig. 9. Accelerating current and accelerating time required by a squirrel-cage induction motor driving a loaded centrifugal pump are compared in (B) for full-voltage starting and 80 per cent and

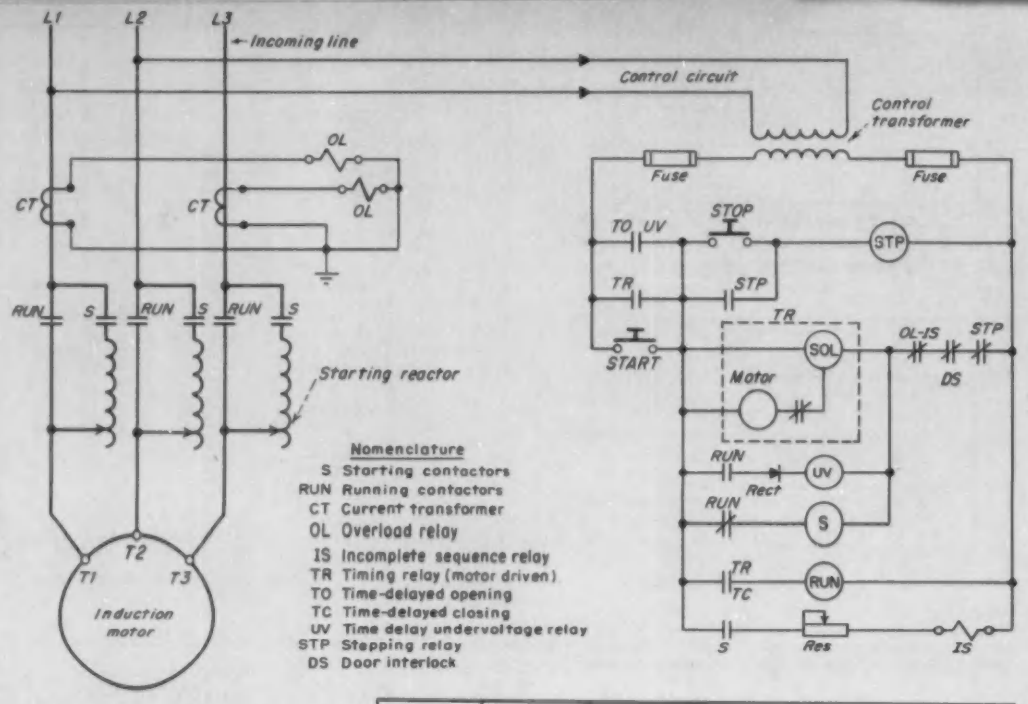


Fig. 10 (Above) — High-voltage primary - reactor squirrel - cage motor controller. Closing of RUN contacts shorts out reactor and applies full voltage without transient interruption.

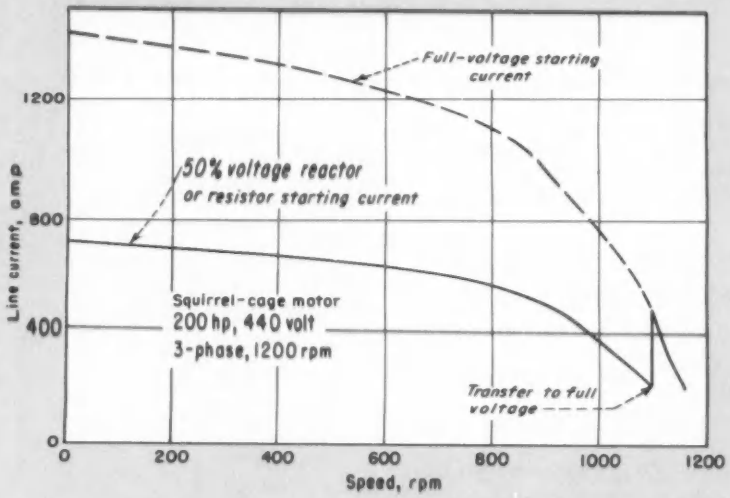


Fig. 11 (Right) — Starting current for 50 per cent voltage resistor or reactor type starting for a 200 hp, 1200 rpm motor. This is twice as much current as required by 50 per cent voltage autotransformer starting, but closed transition of resistor or reactor type from half to full line voltage reduces line disturbance.

65 per cent autotransformer starting.

Applying Autotransformer Controllers. The autotransformer tap and transfer point should be selected so that current at transfer does not exceed reduced-voltage locked-rotor current or the advantages of reduced-current starting are lost.

If the motor has not accelerated sufficiently, the current at transfer to full voltage can be much greater than current taken from the line at the instant of starting. Referring to the example cited in Fig. 7, at zero speed the line current was only 380 amp, but too early transfer at 1100 rpm caused the line current to jump to 550 amp. If transfer had occurred at 1000 rpm line current would have been 800 amp.

Selection of the tap and transfer speed usually must be by trial, using the minimum-voltage starting tap if possible. Most autotransformer controllers are equipped with medium-duty units and are connected at the factory to 65 per cent taps.

Primary Reactor and Resistor Starting

Another method used to reduce starting current connects a reactor or resistor in series with each phase of the motor during the starting period as shown in Fig. 10. Motor current produces a voltage drop across the resistor or reactor thereby reducing motor terminal voltage and the starting current. Line currents drawn by resistor and reactor starting are directly proportional to the reduced voltage at the motor and are consequently higher

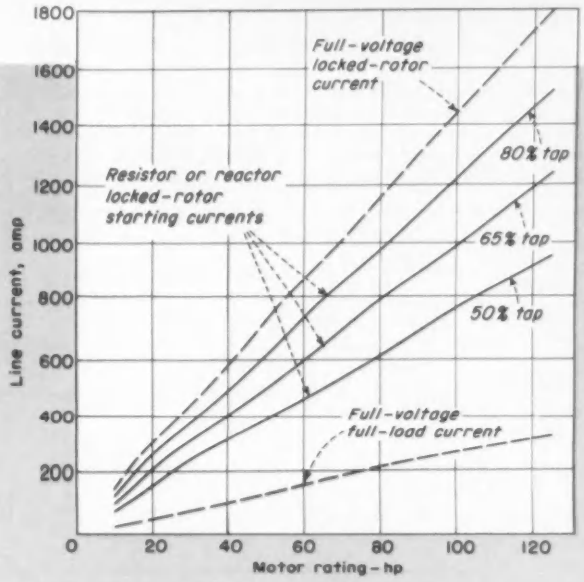
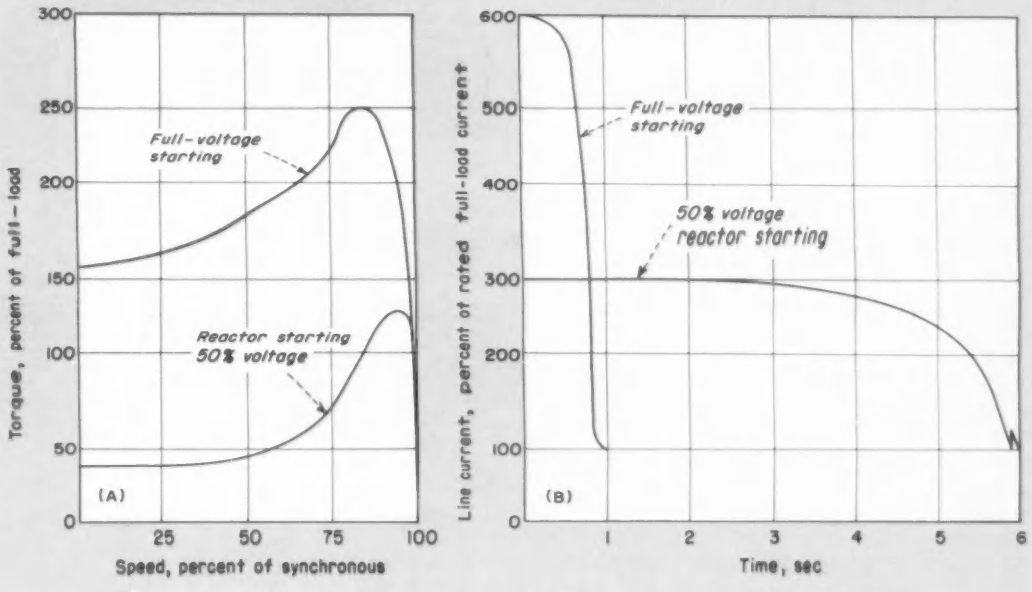


Fig. 12 – Starting currents drawn by 50, 65 and 80 per cent voltage resistor or reactor starting compared to full-voltage starting currents for 10 to 125 hp, NEMA Design B, C and D motors.

Fig. 13 (Below) – (A) Speed-torque characteristics of a squirrel-cage induction motor comparing 50 per cent voltage reactor starting to full-voltage starting; 50 per cent voltage is obtained on locked rotor. (B) Starting current and accelerating time of a squirrel-cage induction motor driving a loaded centrifugal pump, comparing reactor 50 per cent voltage starting with full-voltage starting.



than with autotransformer starting. For example, 50 per cent reactor or resistor voltage limits line currents to 50 per cent of full-voltage values. This current reduction is shown in Fig. 11, which compares current drawn by full-voltage starting with reactor or resistor starting using 50 per cent of motor voltage. Starting currents for motors up to 125 hp are compared in Fig. 12.

For the initial starting period, resistors or reactors remain connected until the motor can be transferred to full line voltage with minimum line disturbance. Transfer timing is accomplished, as with autotransformer

Table VIII – Duty-cycles and NEMA Class Numbers for Resistors in Primary Resistor and Wound-Rotor Motor Starters

Current on First Point, per cent of full load	NEMA Class Numbers						
	5 sec on 75 sec off	10 sec on 70 sec off	15 sec on 75 sec off	15 sec on 45 sec off	15 sec on 30 sec off	15 sec on 15 sec off	Continuous Duty
25	111	131	141	151	161	171	91
50	112	132	142	152	162	172	92
70	113	133	143	153	163	173	93
100	114	134	144	154	164	174	94
150	115	135	145	155	165	175	95
200 or over	116	136	146	156	166	176	96

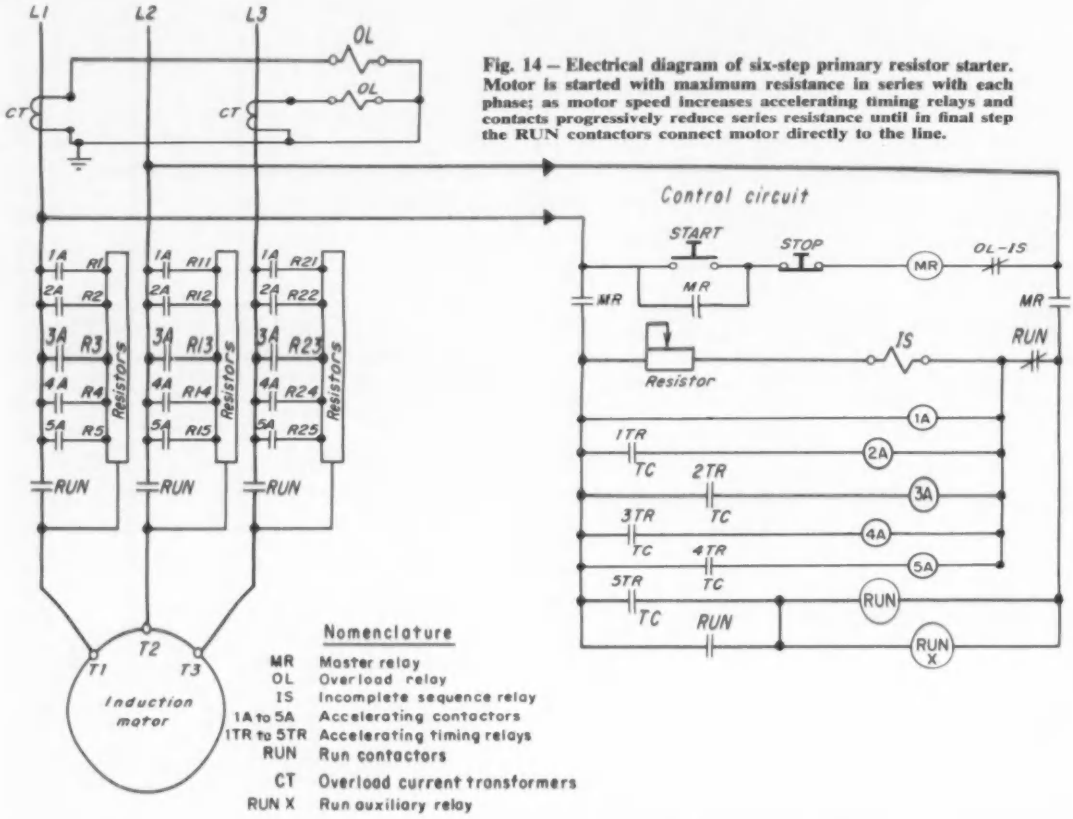


Fig. 14 – Electrical diagram of six-step primary resistor starter. Motor is started with maximum resistance in series with each phase; as motor speed increases accelerating timing relays and contacts progressively reduce series resistance until in final step the RUN contactors connect motor directly to the line.

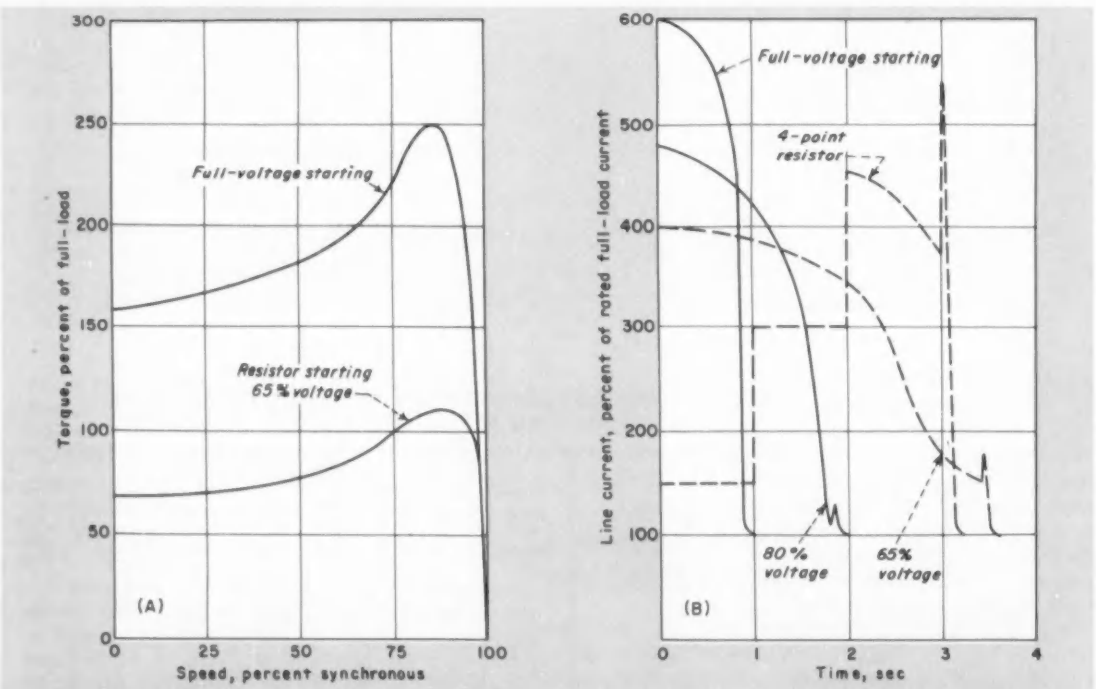


Fig. 15 – (A) Speed-torque characteristics of a squirrel-cage induction motor comparing 65 per cent voltage resistor starting with full-voltage starting; 65 per cent voltage is obtained on locked rotor. (B) Starting currents for full-voltage and three types of resistor starting for a squirrel-cage motor driving a loaded centrifugal pump.

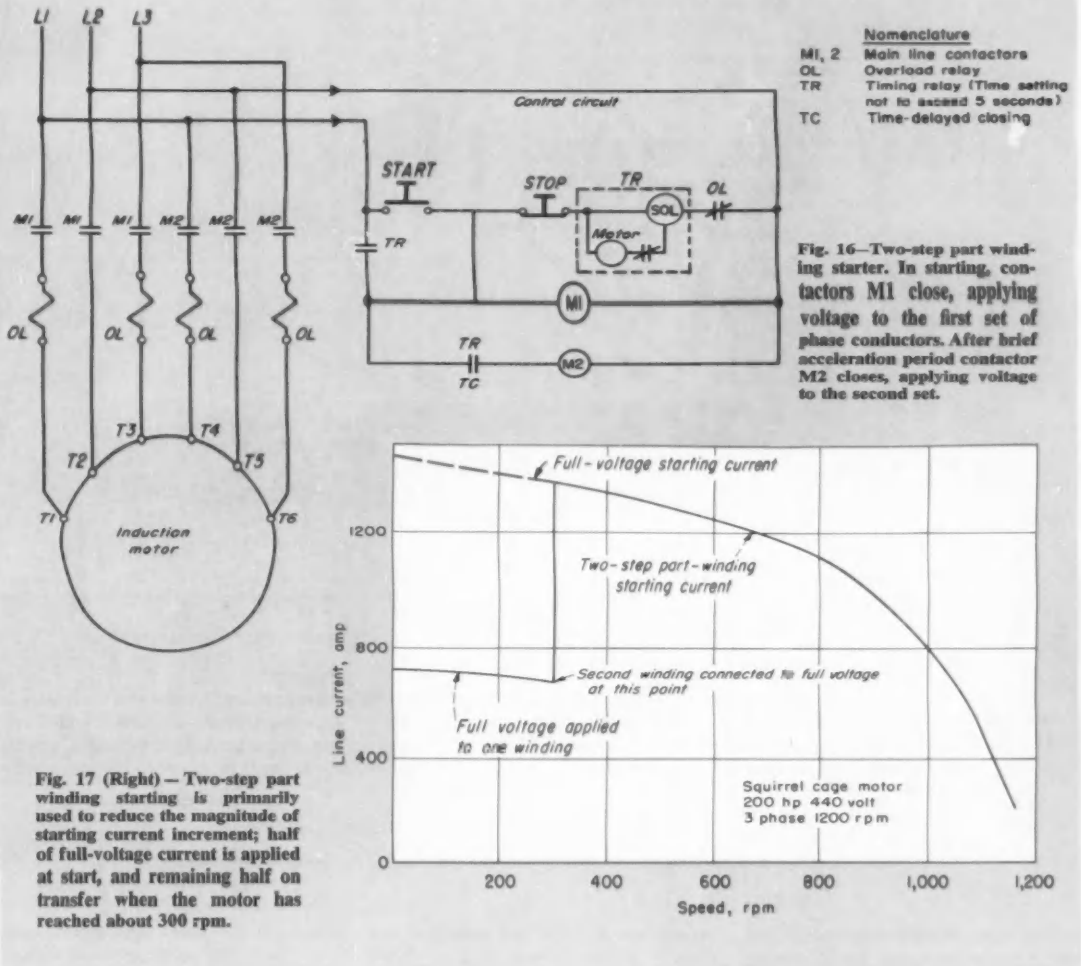


Fig. 16—Two-step part winding starter. In starting, contactors M1 close, applying voltage to the first set of phase conductors. After brief acceleration period contactor M2 closes, applying voltage to the second set.

Fig. 17 (Right)—Two-step part winding starting is primarily used to reduce the magnitude of starting current increment; half of full-voltage current is applied at start, and remaining half on transfer when the motor has reached about 300 rpm.

starting, using time-delay or current relays. However, resistor and reactor starting transfer is accomplished by shorting out these elements and thus occurs without power interruption. After the transfer has been completed, the starting elements are either disconnected from the circuit, or remain shorted out for normal operation.

This closed transition feature can be useful on systems sensitive to small voltage dips. Although the current at transfer may be greater than the starting current, as shown in Fig. 11, the rise is only an addition to the starting current, and not a sudden transient increase from zero as for autotransformer starting. Another advantage is that resistor and reactor values can be chosen to provide balanced phase currents on starting.

Standard reactor and resistor starters are designed for two-step starting; the first step is on reduced voltage, and the final step is to full voltage. Fig. 10 is the electrical diagram of a two-step primary-reactor type squirrel-cage motor controller for 2300 or 2600 volts. On starting, the *S* or starting contacts are closed; for running the *Run* contacts short out the starting reactors, applying full voltage to the motor. Use of reactors produces slightly more torque than with resistors.

Accelerating and torque characteristics for a reactor with 50 per cent voltage are shown in Fig. 13(A). The increase in accelerating time, as compared with full-voltage starting, is shown in Fig. 13(B) for an induction motor driving a loaded centrifugal pump.

Although most resistor and reactor starters use two-step starting, these controllers are readily available with more than two starting steps. The principal advantage is a reduction in the current change per step as the number of steps is increased. Fig. 14 is the electrical diagram of a six-step primary-resistor starter. The starting resistors have duty cycle limitations as listed in Table VIII for various NEMA classes.

Speed-torque characteristics of a motor with a resistor starter using 65 per cent standstill starting voltage is compared with full-voltage starting for the same motor in Fig. 15(A). Starting currents and starting times for a squirrel-cage motor driving a loaded centrifugal pump are compared in Fig. 15(B) for full-voltage and for resistor

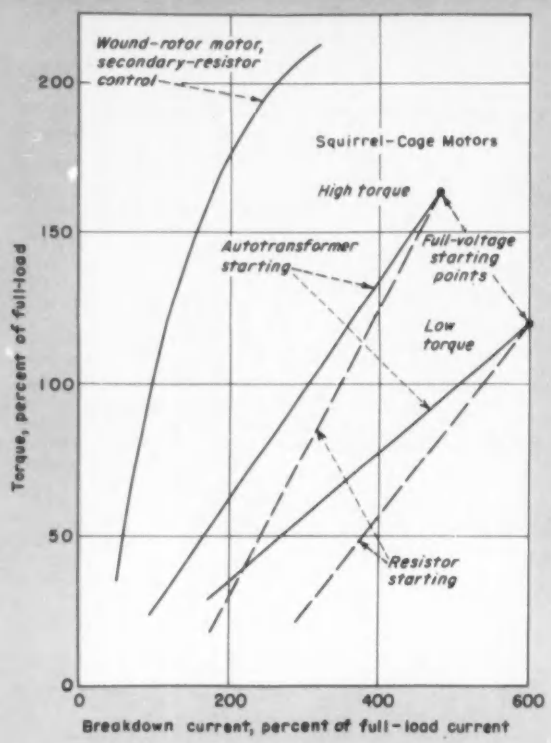


Fig. 18 – Starting currents for wound-rotor motor using secondary resistance control are much less over a wide range of starting torques than for either high or low-torque squirrel-cage motors using either autotransformer or primary resistor starting methods.

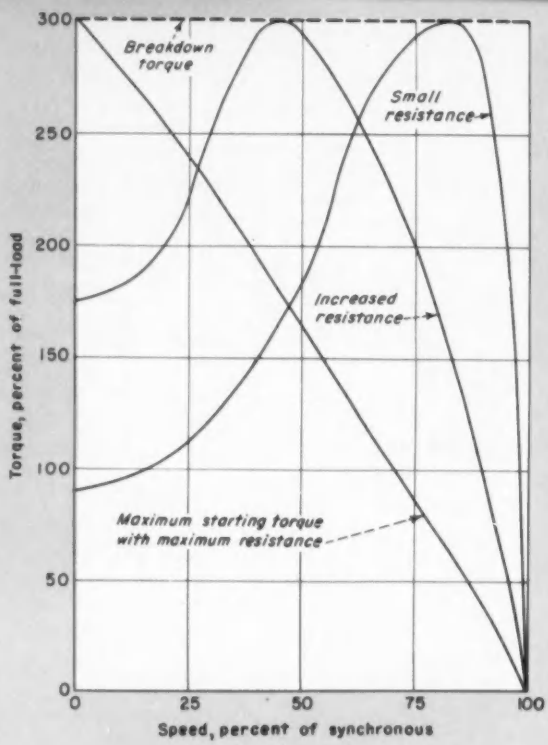


Fig. 19 – Speed-torque characteristics of wound-rotor motor are varied by changing value of resistance in rotor circuit. Maximum starting torque is obtained when the external resistance per phase is equal to the rotor reactance per phase at standstill.

starting using 65 per cent and 80 per cent voltages. Current drawn during four-step resistor starting is also shown.

Resistor-type starters are less expensive than the same rating in a reactor type, but are available only in low voltage ratings for motors having full-load currents under 600 amp. Problems of insulation, space factor, and power losses make use of this type starter impractical for higher voltages or currents.

Part-Winding Starting

Stator windings of most integral-horsepower a-c motors are wound using two or more conductors in parallel for each phase of the machine. The conductors for each phase are normally connected together inside the motor, and only a single terminal lead brought to the outside. For normal full-voltage starting, line voltage is applied to all conductors of each phase at the same instant.

It is possible, however, to terminate each conductor of each phase on the outside of the motors. A two-step part winding starter, Fig. 16, can then be used to apply full voltage to first one phase winding, then to both. This method results in reduced starting current.

The current drawn by each set of conductors is inversely proportional to the number of conductors per phase. When there are two conductors per phase, each conductor carries about half the motor current. When the first set is connected, starting current is approximately half the normal current, as shown in Fig. 17.

Part-winding motors are normally started by connecting each set of phase conductors to the line in sequence until all conductors for each phase are in parallel for normal operation. The sequence is usually controlled by timing relays set for short time intervals of 1 to 5 sec. The purpose of part-winding starting is not primarily to reduce accelerating current, but rather to provide smaller increments of starting current. The individual phase conductors are not capable of carrying current for more than a few seconds. On three-step starting the first-step interval is often set for 1 sec or less. Motors usually do not break away under these conditions but the starting current is divided into a series of smaller increments.

Part-winding starting is not widely used. Some sizes of low-voltage motors and controllers are available, but high-voltage units are seldom applied except in some phases of the cement industry. Controllers for use with part-winding motors are usually lower priced than similar controllers of the autotransformer, reactor, or resistor types because current-limiting elements are not required. Motors for part-winding starting are generally more expensive.

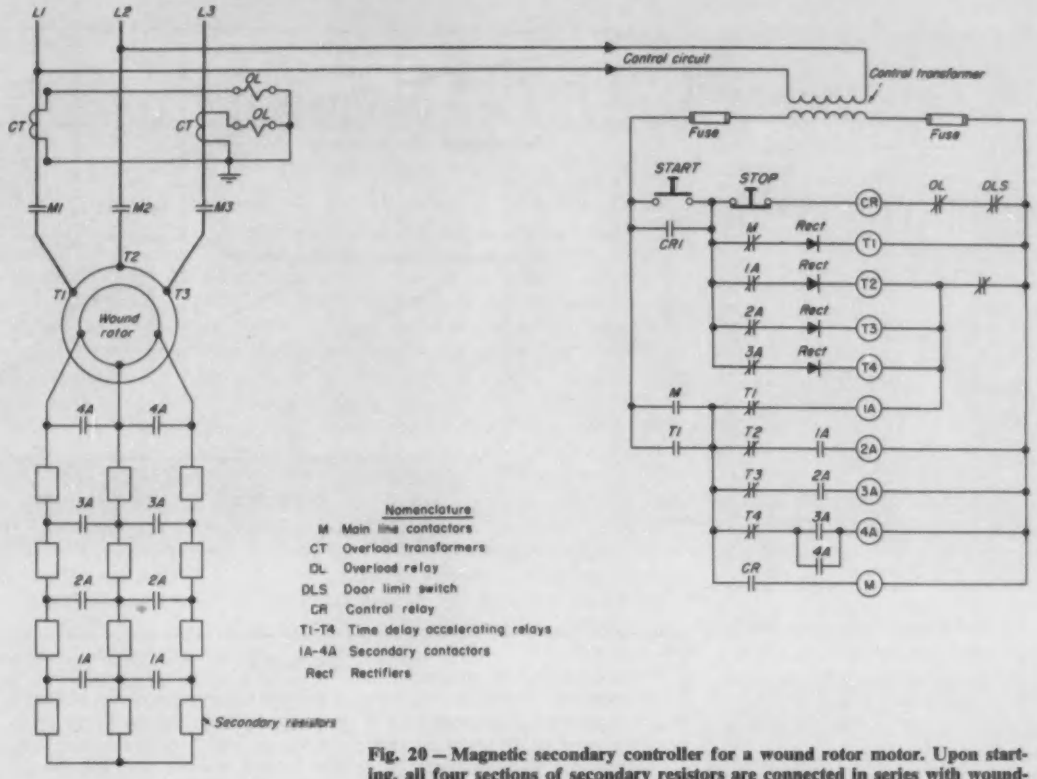


Fig. 20 — Magnetic secondary controller for a wound rotor motor. Upon starting, all four sections of secondary resistors are connected in series with wound-rotor phase windings. As motor accelerates, timing accelerating relays T1 and T4 progressively short out resistors, beginning with the 1A bank, and ending with 4A, at which point all resistance is out of the rotor circuit.

Wound-Rotor Motors

Where high torque is required to break away a heavy machine load, the starting current for a suitable squirrel-cage motor and controller may be too high for the system. A wound-rotor motor can deliver the same starting torque with less initial starting current. Wound-rotor motors can be started across the line; reduced-voltage starters can provide smooth and efficient acceleration. Starting current for a wound-rotor motor using secondary resistance control is compared in Fig. 18 to squirrel-cage motors using auto-transformer and primary resistor starting.

In construction the wound-rotor induction motor differs from the squirrel-cage only in the rotor. Where the squirrel-cage motor has short-circuited bars the wound-rotor motor has windings, usually three phases. Leads from these windings are brought out to slip rings. By connecting values of external resistances between the three slip rings, the torque-speed characteristics of the wound-rotor motor can be changed as shown by the curves in Fig. 19. By connecting the proper amount of external resistance into the rotor circuit, breakdown torque may be obtained at standstill.

In a wound-rotor motor the stator is commonly called the primary and the rotor the secondary, because under locked-rotor conditions the motor is a transformer with a ratio which depends on motor design. Since the primary is the same as that of a squirrel-cage motor, the primary control requires a standard motor starter of the full-voltage type. The secondary control is usually by manual drum or magnetic controller. In the magnetic controller the drum switch is replaced by a series of secondary accelerating contactors, as shown in Fig. 20 for a typical controller.

These motors are started with the total resistance in the circuit. By shorting out sections of the secondary resistance in sequence, the motors accelerate through a series of definite speed-torque characteristic points corresponding to the number of resistance steps and the value of the resistance at each step. Fig. 21 shows starting current variation for a five-step starter on a 200 hp motor.

Secondary characteristics and control components can be identical for similar motors of equal horsepower rating even though the stator voltage ratings may be widely different. While the number of starting steps for various size motors has been standardized, Table IX, the number of steps can be increased or decreased. If smooth starting is important, a greater number of steps are used.

Table IX – Standard Starting Steps for Wound-Rotor Motors

Motor H.P.	Number of Secondary Points	Maximum Secondary Current, Amp
20-75	3	225
100	4	225
125	4	225
150	4	225
200-300	5	450

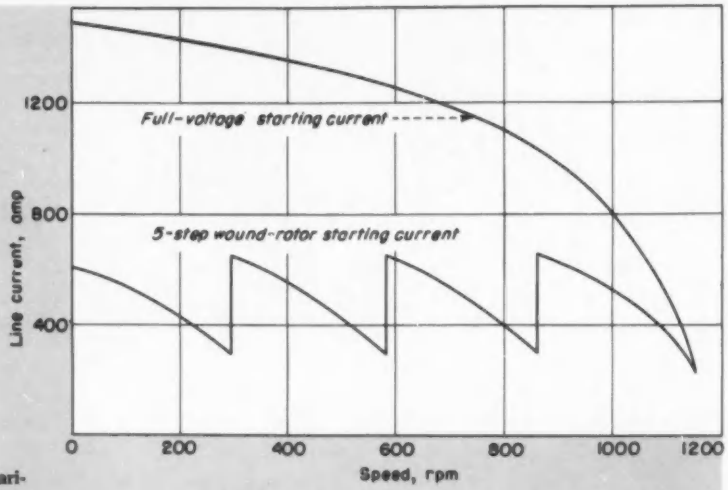


Fig. 21 (Right) – Starting-current variation for a five-step wound-rotor motor.

In a recent application three 300-hp wound-rotor motors were used to drive a mile-long conveyor belt. To avoid excessive stress on the belt in starting, the motors were accelerated to full speed in 36 steps. Stepless starting can be obtained by the use of liquid rheostats instead of secondary resistors and shorting switches; higher cost of this type of controller limits it to special applications.

Starting currents of wound-rotor motors can be limited to specific values by the design of secondary resistor banks. Duty cycle of the application determines the required thermal capacity of the resistors. NEMA has established classes of resistors rated according to duty cycle (previously listed in Table VIII). Requirements for lower inrush currents or more severe duty cycles increase both size and cost of secondary resistor banks.

If speed regulation of the wound-rotor motor is required, the resistors must be designed for continuous duty for the steps on which speed control is used. Regulating-duty resistors are designed for a fully loaded motor; if the motor draws less than full-load power, the specified degree of speed regulation cannot be obtained without additional resistance.

Wound-rotor motors and their controllers are more expensive than squirrel cage units, but their use should be considered when facing severe starting problems.

EDITOR'S NOTE

Background: Several earlier articles in Product Engineering present reference data on starting characteristics of three-phase motors and the design problems involved in motor starting, including the inertia of motor and load, advantages and limitations of various control systems, and selection of control components.

Additional data on starting characteristics of principal types of squirrel-cage motors are given in "Significance of WK^2 and How to Calculate It," in Annual Handbook for 1954 on page H-24. See also "Adjustable-Frequency Multi-Motor Drives," May 1952 page 146, for characteristic speed-torque curves of squirrel-cage and 6-pole synchronous motors. Starting performance of standard motor types is tabulated in "Applying Synchronous Motors to High Inertia Loads," March 1951 page 141.

A discussion of starting and torque characteristics for a number of different types of machine loads is included in "Synchronous Motor Drives" in the Annual Handbook Issue for 1956 on page H-23. A recent article, "Axial-Air-Gap Motors for Machine-Tool Drives" September 1955 page 129, compares starting torque and acceleration of these high-WK^2 motors with like characteristics of conventional motors.

"Power Control Circuits and Their Components," in the Annual Handbook Issue for 1956, page H-17, describes and compares various types of manual and magnetic controllers for a-c motor starting, including full-voltage, and resistor and autotransformer reduced-voltage types. Basic arrangements of starting control components are also shown, and factors which determine choice of best controller components and circuits are summarized in a useful chart which also includes d-c controllers.

Examples of sequential starting of motors to prevent excessive full-voltage starting currents are described and illustrated in "Pneumatic Time-Delay Relays" January 1956 page 174. "Motor Overload Relays," January 1955 page 177, presents the fundamental problems and solutions for selecting bimetal thermal overload devices to protect motors against excessive overload or starting currents. Means of interlocking the interconnected operations of several motors in a single machine are described in "Pilot Control Devices," May 1955 page 187.

Other phases of the problem of maintaining constant line voltage despite heavy starting currents are also covered in "A-c Voltage Regulators," February 1955 page 135. This article discusses selection and application of regulators capable of maintaining constant voltages on loads from 2 to over 100 kva.

Design Engineers Get Their Own Show

This year the Design Engineer will have his place in the sun. Sponsored by the Machine Design Division of the American Society of Mechanical Engineers, and backed by the four major Design Engineering publications, the first Design Engineering Show and Conference will be held this May 14-17 at Convention Hall in Philadelphia, Pa. The Show—the first of its kind ever held—has evolved from another exposition called the Basic Materials Exposition, and will now be devoted exclusively to the study of industry's problems in the design engineering field.

The ASME has appointed the chief editors of the four leading publications in the design engineering field as the Papers Committee to draft a program for the four-day conference. These editors are: G. F. Nordenholt of *Product Engineering*; F. J. Oliver of *Electrical Manufacturing*; Colin Carmichael of *Machine Design*; and T. C. DuMond of *Materials & Methods*.

Tentative plans indicate that the first day of the Conference will be devoted to a discussion of "Cost Reduction in Product Design," while the second day's session will be a panel discussion on finding suitable men for the design engineering field, as well as methods of training them.

Two papers will be presented on the third day. One will deal with problems relating to the selection of engineering materials, and will consider how factors such as mechanical efficiency and economy influence the choice of materials. The second paper will discuss methods of miniaturization, as well as its inherent problems in design and manufacturing.

The topics for discussion on the last day will be inventions and patents. One paper will tell of the awarding of recognition and compensation for inventions developed by company employees. For the second paper, a patent attorney will detail the rights of an employee with his inventions.

Over at the exhibit, all types of equipment which go into the manufacture of a finished product will be on display. Displays will include parts, components, finishes, basic materials, as well as testing machines, x-ray machines and other equipment having specific design engineering applications. The Show is the first to be devoted exclusively to the design engineer, and henceforth, on an annual basis, will show the latest developments and techniques used in this field. Almost all industries should have a major interest in the exhibits and the conference. At the exhibit, approximately 150 companies will show components and materials used in the manufacture of end products.

As Mr. Robert M. Conklin, Chief of the Mechanical engineering division of Battelle Memorial Institute stated: "Each new development in automatic, high speed production equipment presents many new design problems. As design engineering improves, the public is benefited by new, better, and less expensive products. We hope to stimulate industrial thinking and planning for better design engineering by this national conference on this subject."

The amount of money invested in the basic industrial research in recent years points up the importance of the design field. In 1954 this investment reached an annual rate of $4-billion. This figure is expected to increase to $13-billion by 1965.

Those wishing to obtain more information should write to the managers of the show: Clapp & Poliak, 341 Madison Ave., New York 17, N. Y.

GEORGE F. NORDENHOLT,
Editor, *Product Engineering*

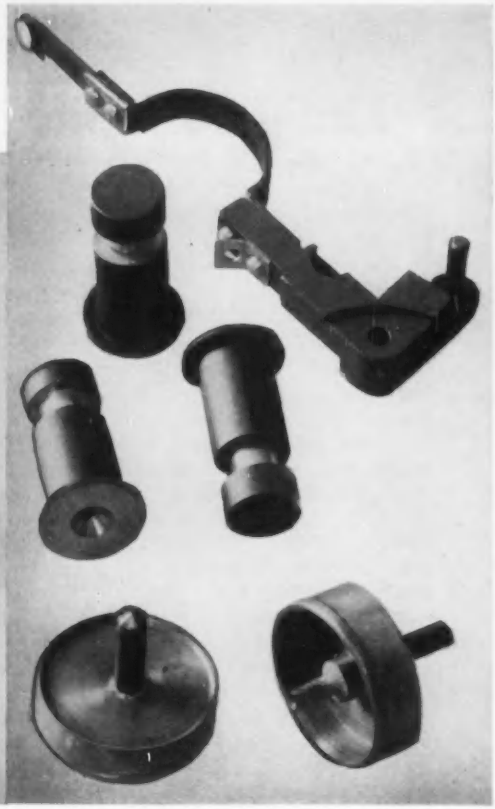
FRANK J. OLIVER,
Editor, *Electrical Manufacturing*

COLIN CARMICHAEL,
Editor, *Machine Design*

T. C. DuMOND,
Editor, *Materials & Methods*

SOLID-FILM LUBRICANTS

These new lubricants offer the high load carrying capacity of boundary lubricants, frictional properties of light oil and are relatively independent of temperature from —100 to 1000 F. Principal limitations are lack of heat dissipation capacity and flushing action.



RALPH E. CRUMP, ELECTROFILM, INC.

SOLID-FILM LUBRICANTS should be considered when an application falls into one or more of the following categories:

1. Parts or bearings to be lubricated are in inaccessible locations.

2. Operating temperatures are extreme; that is, loss of film strength at high temperature, or high coefficient of friction at low temperature precludes using oil or grease. Solid film lubricants are independent of temperatures between −100 and +600 F. Special films are available for temperatures above 1000 F.

3. Systems are exposed to dust or other contaminants which impair operation. Solid lubricants are dry and do not attract dust or lint.

4. Non-continuous operating systems make maintenance schedules expensive over long storage periods.

5. Equipment is located in environments such as fuels, solvents and liquid oxygen which are reactive to conventional lubricants.

6. Bearings are likely to be overlooked during lubrication schedule; hermetically sealed units.

In addition, dry film lubricants offer other important advantages in certain types of applications. For example, they prevent galling between metal surfaces such as aluminum and titanium, which are particularly susceptible to such action, and they are used as a lubricant in processes

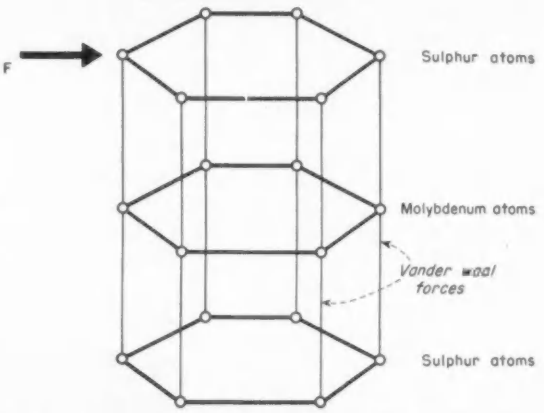


Fig. 1—Crystal structure of molybdenum disulfide. Low shear strength and low coefficient of friction is a result of atomic forces on each plane being stronger than those between planes.

such as wire drawing. Furthermore, there is evidence that although a solid film lubricant will not prevent fretting corrosion completely, it can often delay this corrosion for a period of time exceeding the required life of the part.

What Are Solid Lubricants?

Solid lubricants generally consist of fine powders having inherent lubricating properties. The type described herein are mixed with a binder—generally a resin selected be-

Table I—Coefficient of Friction

COMPOSITIONS		
90% MoS_2, 2% graphite-resin bonded on steel, rubbing against bare steel	0.06–0.04	Kinetic at 72 rpm approx 80,000 psi and dry
100% MoS_2, bonded on steel, rubbing against bare steel	0.045–0.038	Kinetic at 72 rpm approx 80,000 psi and dry
90% MoS_2, 10% graphite, very low resin to pigment ratio, bonded on steel	0.04–0.03	Kinetic at 72 rpm approx 80,000 psi and dry
100% MoS_2, bonded on steel, rubbing against aluminum	0.08	Kinetic at 72 rpm approx 80,000 psi and dry
50% MoS_2, 50% graphite, bonded on steel, rubbing against bare steel	0.087	Kinetic at 72 rpm approx 80,000 psi and dry
90% MoS_2, 10% graphite, bonded on steel, rubbing on bare steel	0.0715	Static at 80,000 psi
COMPARISON DATA		
Steel on steel	0.45–0.06	Dry
Brass on steel	0.44	Dry
Babbitt on mild steel	0.33	Dry
Glass on glass	0.4	Dry
Steel on steel, MoS_2 in silicone varnish	0.06	Ref NACA Tech Note 2802
Steel on steel-graphite, bonded	0.17	Ref NACA Tech Note 1578
Steel on steel-MoS_2, bonded	0.07–0.11	Ref NACA Tech Note 1578
Steel on steel with E.P. oil	0.042	Boundary lubrication
Steel on steel with SAE 20	0.044	Boundary lubrication

SYMBOLS

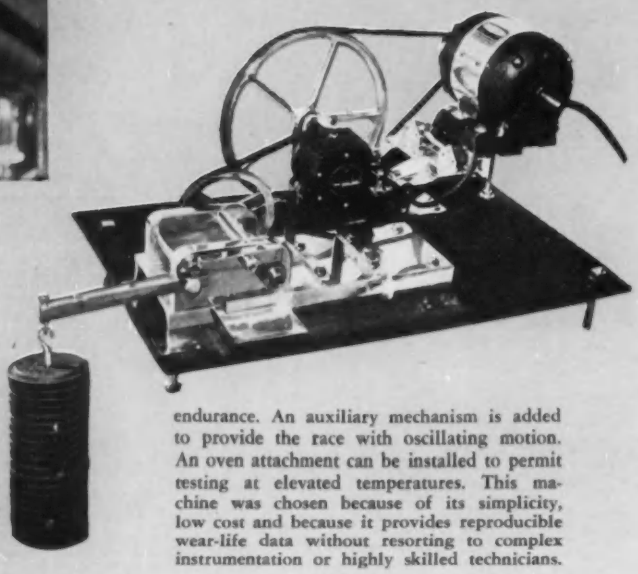
S_m	shear strength of metal
S_f	shear strength of film
F	friction force
W	load
A	area
μ	coefficient of friction

cause of its high shear strength and abrasion resistance—and applied to a metallic surface with heat. Typical solid lubricants are molybdenum disulfide, lead iodide, silver sulphide and tungsten disulfide. Titanium disulfide, lead chloride, and sodium sulphate are laminar-layered but do not possess the requisites necessary to form solid lubricants.

These lubricants derive their special properties from their unique laminar-lattice crystal structure which imparts low shear strength and makes it possible to form a regenerative lubricating film on mating surfaces. The crystal structure of a widely used pigment, molybdenum disulfide, is shown in Fig. 1. The interatomic forces on each plane are much greater than the forces between planes, resulting in a low shear strength between planes and therefore a low coefficient of friction.

Even though particles are in random orientation in a solid film, as soon as two coated surfaces are rubbed to-

Test Equipment and Procedure



The mechanism used to evaluate different solid film lubricants and to compile the performance data included in this article is a modified "Timken Tester." It uses the outer race of a commercially available tapered roller bearing as a specimen. This rubs against the full width of a metal block. Load is applied through a simple lever mechanism providing a mechanical advantage of 28 to 1. The solid film lubricants are applied to the outer surface of the test race. When testing the application on steel (R_c 55 to 60) using a steel block of similar hardness, the contact area is approximately 0.007 sq. in., which produces a unit load of 80,000 psi with 20 lb applied to the hangar.

Speeds and loads are varied to study film endurance. An auxiliary mechanism is added to provide the race with oscillating motion. An oven attachment can be installed to permit testing at elevated temperatures. This machine was chosen because of its simplicity, low cost and because it provides reproducible wear-life data without resorting to complex instrumentation or highly skilled technicians.

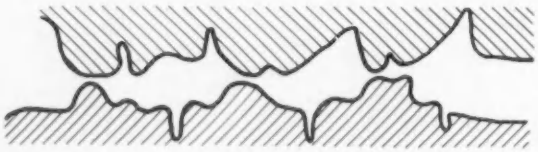


Fig. 2—Enlarged view of two metallic surfaces in contact.

gether, the particles are forced into alignment. This is evidenced as an increase in reflected light on an initially opaque, coated surface and is commonly called "burnishing."

Two moving surfaces in contact are shown in Fig. 2. The actual area of contact is several thousand times smaller than that apparent by the over-all geometry. The actual area of contact, A, is directly proportional to load W and inversely proportional to the flow pressure or yield of the metal, P_m.

$$A = W/P_m \tag{1}$$

For metal sliding on metal the frictional force F is

$$F = AS_m \tag{2}$$

Dividing Eq (1) by Eq (2),

$$\frac{F}{W} = \mu = \frac{AS_m}{AP_m} = \frac{S_m}{P_m} \tag{3}$$

Thus, μ is independent of contact area, and can be reduced to a minimum either by minimizing the shear strength of the bearing or making the flow pressure a maximum, consistent with good design. This is a partial explanation for the success of babbitt (low shear) bearings. It is apparent that the low shear requirement can be satisfied by introducing between two bearing members a film which has a shear strength lower than that of the sub-metal, but with maximum adhesion to the metal.

Eq (2) can be expanded by assuming that the surfaces are covered by a film such that only a fraction of the contact area remains metal to metal

$$F = (\alpha S_m + (1 - \alpha)S_f)A \tag{4}$$

where α is the ratio of apparent area to actual area of contact. From Eq (3)

$$\mu = \frac{F}{W} = \alpha \frac{S_m}{P_m} + \frac{(1 - \alpha)}{P_f} S_f \tag{5}$$

With a complete film there is no metal-to-metal contact and α approaches zero. Under this condition, the first term in Eq (5) approaches zero and the coefficient of friction becomes equal to the shear strength of the solid film lubricant divided by the flow pressure of the film. A

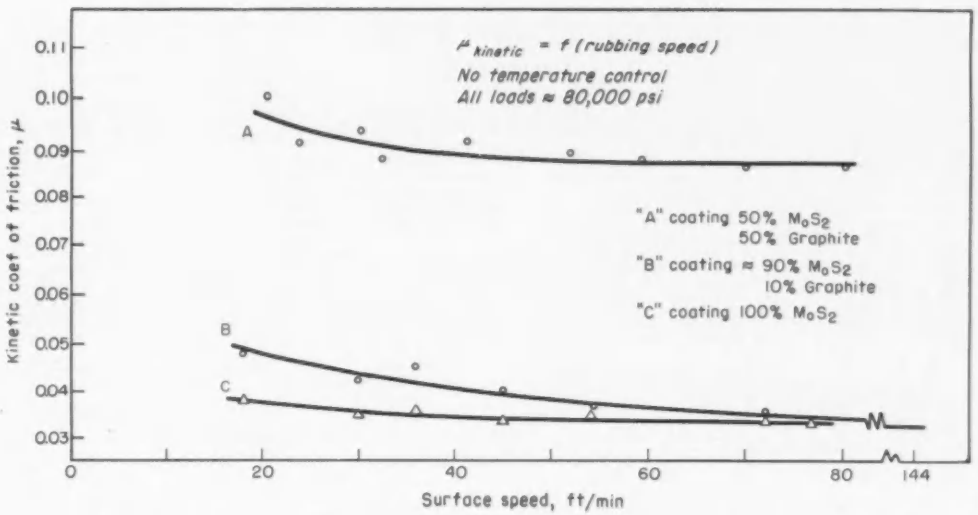


Fig. 3—Coefficient of friction is almost constant with speed. As graphite content increases, however, friction rises sharply.

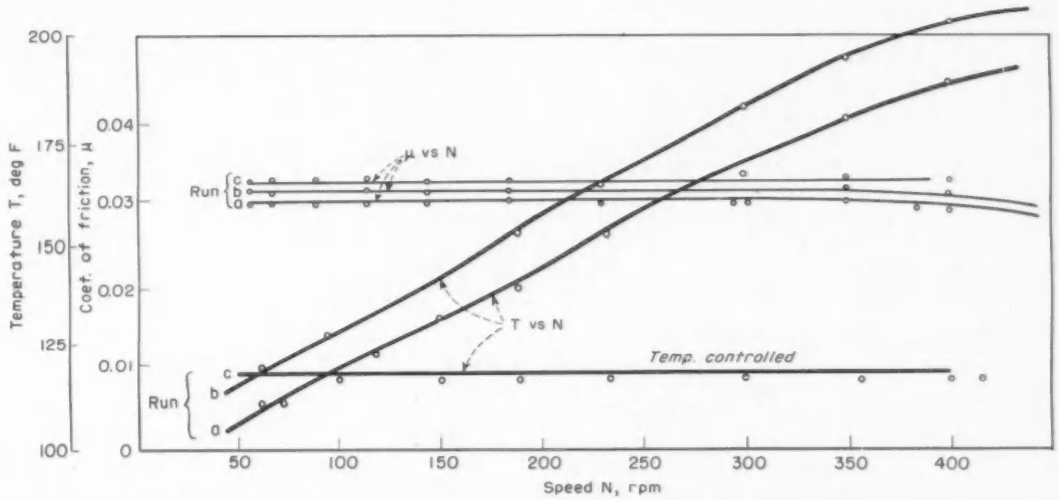


Fig. 4—Effect of temperature on coefficient of friction. In run (a), speed was increased from 50 to 400 rpm on a 1.375 in. dia. specimen. Although temperature increased from 105 to 188 F, μ was constant within almost 5 per cent. Run (b) was similar. In (c), temperature was held constant and μ was constant as speed increased.

practical example of Eq (5) is as follows: Bare, clean steel rubbing on clean steel will have a coefficient of friction of approximately 0.5. This value reduces to about 0.04 when a solid film lubricant is added between the surfaces.

What Factors Affect Performance?

The formulation of a solid film lubricant is a compromise between the properties of the solid and the properties of the binder. The principal function of the binder is to form a thin, homogeneous film having strong adhesion to the metal and good cohesive properties so that it can resist the abrasive or frictional forces to which it is subjected. Commercial lubricants are usually compounded to give maximum wear life.

The variation in the coefficient of friction with rubbing speed for four films is illustrated in Fig. 3. As the graphite content increases so does the coefficient of friction. Published values of μ for dry MoS_2 powder are 0.02, for graphite, 0.05.

The effect of temperature on coefficient of friction is shown in Fig. 4. The temperature accrued in test specimens is a function of rubbing speed, but unlike conventional lubricants whose viscosity is sensitive to temperature and whose coefficient of friction is linked to shear forces and viscosity, the coefficient of friction of solid film lubricants remains virtually unchanged from −100 to +650 F. Wear life, however, decreases at higher temperatures. Coatings are presently being developed that will operate satisfactorily at 1000 F.

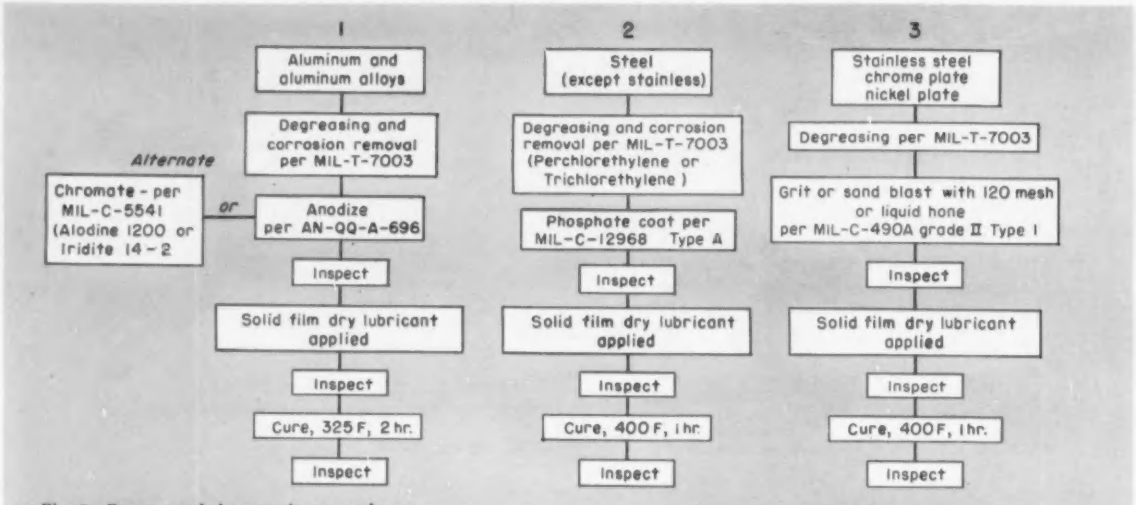


Fig. 5—Recommended processing procedures.

How Are Solid Lubricants Applied?

The care and technique employed in applying a film to a large extent decides the performance. In general, the surface to be coated should have a surface finish of 32 to 60 microinches rms. The irregularities increase adhesion and provide for a better chemical pretreatment, if one is specified. Process charts, Fig. 5, specify preferred surface treatments for various metals. One advantage of the need for a rough surface before application is that finishing operations such as grinding and honing can often be eliminated.

The dimensional change immediately following this treatment depends on the metal, its hardness and the processes used. For steels the change is usually less than 0.0005 in., which is negligible in most applications.

Most metals must then be chemically processed to increase the corrosion resistance and provide a chemical etch and/or a deposit that will enhance adhesion and wear life. A typical example is the iron manganese phosphate conversion defined in the Military Spec. C-12968. Fig. 5 also suggests conversions for other metals.

The solid film lubricant can be applied either by spraying or dipping. The choice depends upon desired coating characteristics and wear requirements. Thickness can usually be controlled more accurately by spray gun than other methods. By controlling the solids content, and pressure, a coating can be deposited to within $\pm\frac{1}{2}$ of one ten thousandths of an inch in thickness. A properly applied film should be no more than 0.0005 in. nor less than 0.00015 in. for good wear life.

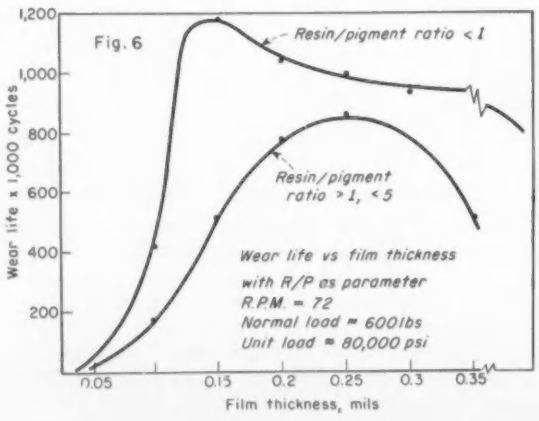
Since most films are compounded of thermosetting resins, they must be cured at temperatures high enough to polymerize the resin. Adhesion, coefficient of friction, and wear life are directly proportional to the degree of polymerization.

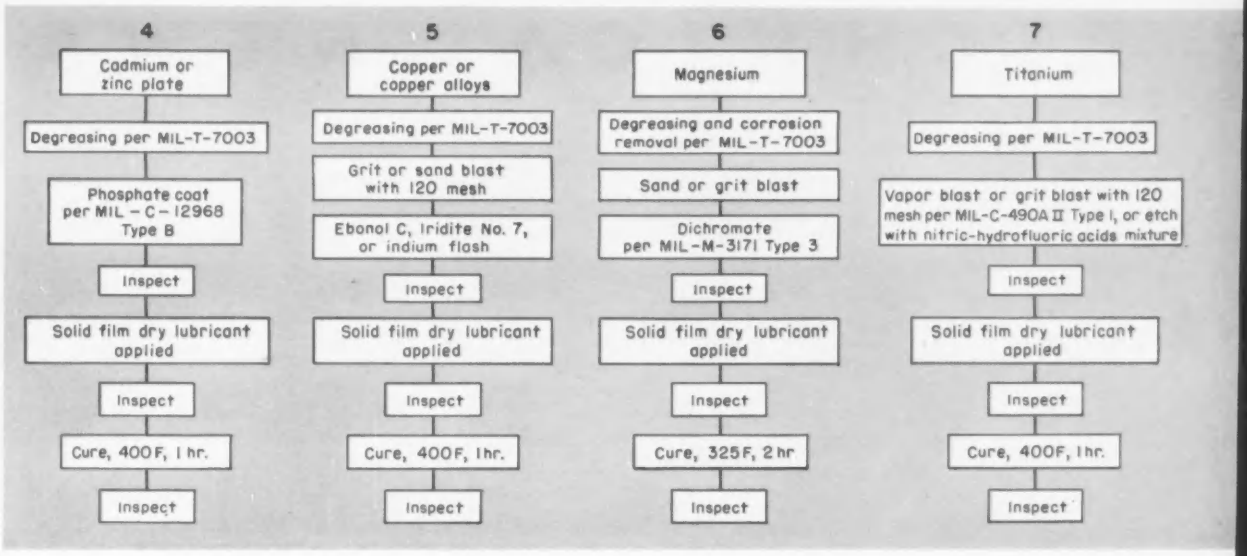
Cleanliness is essential. Many plants have installed continuous processing equipment that includes degreasing, chemical etch with the attendant rinses, pretreatment tanks, automatic spray equipment, and infra-red ovens, with the parts held in place and moving from station to station on an endless belt.

How Long Will Solid Lubricants Last?

Wear life is also a function of load, speed and temperature, and is affected by film thickness, humidity, film composition, metal pretreatment, properties of the metal to which the film is applied, and various ambient conditions such as the presence of oil, contaminants, or oxidizing atmospheres.

It has been found that resistance to wear is a maximum for a particular resin pigment ratio and in a particular thickness range. Fig. 6 shows the results of wear tests for different pigment ratios and coating thicknesses. The fact that life decreases as film thickness increases beyond the maximum is probably explained by the fact that as the thickness increases cohesion is less than the adhesion of the film to the base. The net result is larger wear particles and shorter life. Also, composition such as resin-solvent,





resin modifiers, particle size and shape, all influence wear and each must be optimized for maximum life.

The dependence of life on load is not entirely understood. Little empirical data have been reported. Fig. 7 shows wear life decreasing with increasing load. The test specimen in this instance oscillates through a 40 deg arc approximately 600 cycles per min (motion and load, typical of rod-end bearings including plain spherical bearings). The load is continuous. The coating studied was 90 per cent molybdenum disulfide and 10 per cent graphite, bonded in thermosetting resin, applied over a phosphate conversion coating as per Mil-C-12968.

That film life is inversely proportional to velocity is shown in Fig. 8. No attempt was made to control the temperature of the test specimen as velocity was increased. This may account for life falling off at the high cyclic speed.

In general, wear life is independent of temperature up to the temperature at which the film was cured, it then decreases as temperature increases. This fact is motivating research in high temperature resins and binders. Tests are now being conducted on films cured at 1000 F. It is expected that these films will operate continuously at temperatures of 500 F or higher.

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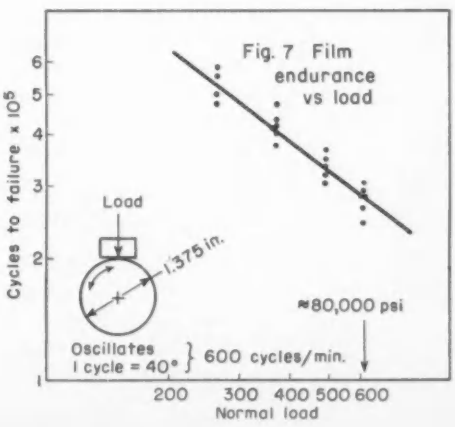
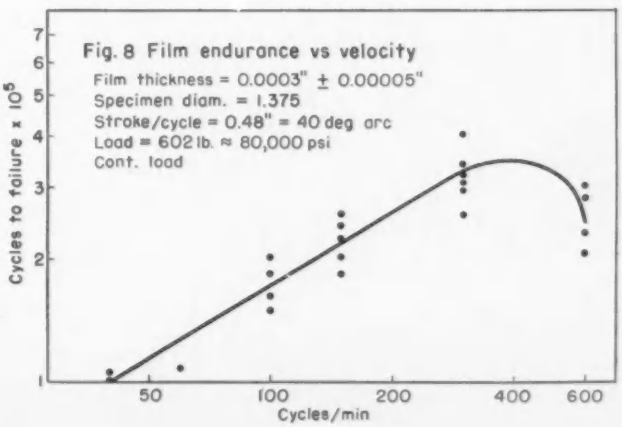
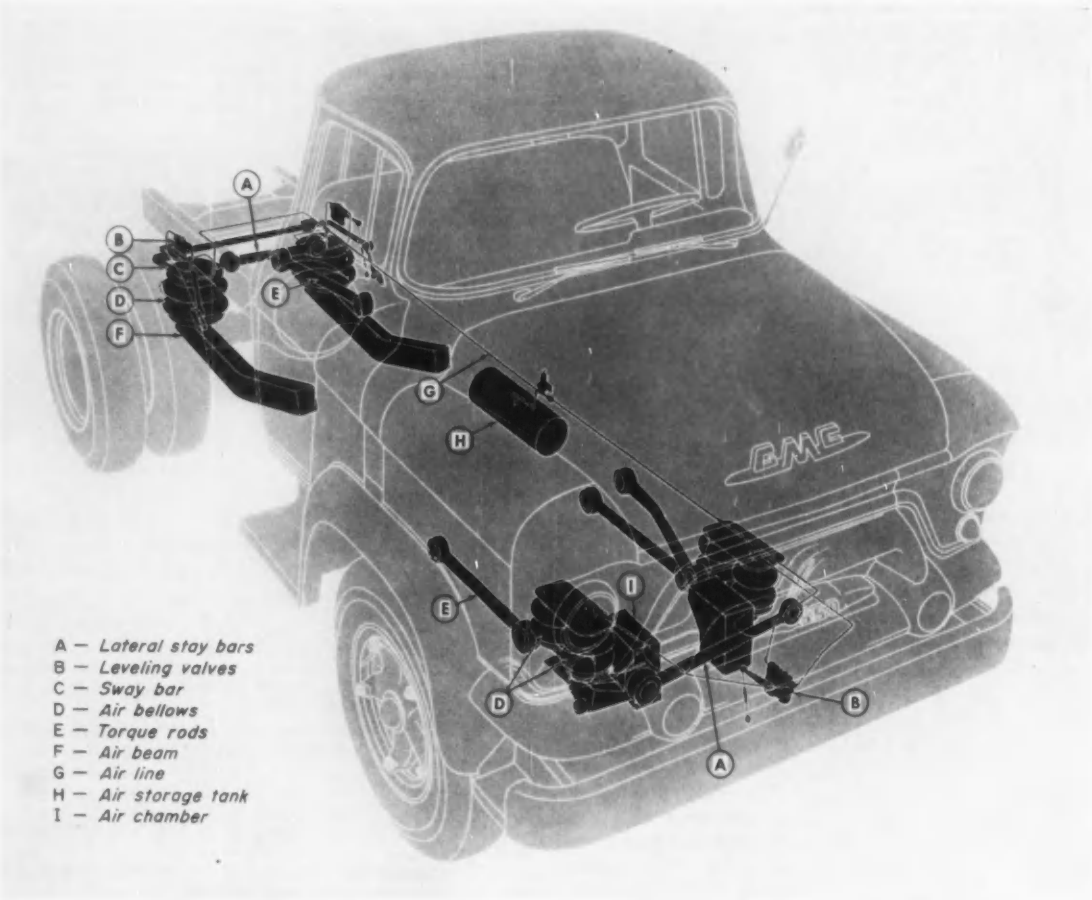




TECHNICAL NEWS


A — Lateral stay bars
B — Leveling valves
C — Sway bar
D — Air bellows
E — Torque rods
F — Air beam
G — Air line
H — Air storage tank
I — Air chamber

Air-Filled Suspension System Ready for 1956 Trucks—

Air-filled rubberized bellows will replace conventional metal leaf springs on GMC trucks late this year when General Motors will go into production on this new suspension system. GM estimates that it will have a life of about one million road miles.

Now being tested on a truck-trailer combination, the air suspension system is composed basically of air bellows, leveling valves, air beams, air chambers, and an air storage tank.

The tractor has a total of six bellows, four in front and two over the rear axle. Two small bellows are mounted on each end of the front axle and a large bellows at each end of the rear axle (see above). Four large bellows are used to support the trailer. Two are mounted on each side of the trailer between the axle and trailer's body.

Compressed air is supplied to the bellows, air beams, and air chambers form the tractor's air system. It flows from the storage tank to the leveling valves that meter the air into the bellows, beams and chambers. Air is available to the air suspension system from the supply tanks only when pressure has been developed to maintain a safe margin for the air brake system. Failure of any part of the suspension system will not cause a loss of vehicle control. If a failure does occur, the frame rests on heavy rubber blocks, and all linkage relationships are maintained.

If there is an increase in the trailer load, the valves send air into the bellows. As the air decreases, the valves release air from the system. Torque rods, a sway bar, and lateral stay bars maintain the positions of each axle against lateral, longitudinal and torsional movement. All linkage is mounted in rubber.

In the experimental GMC tractor-trailer combinations, the trailer has 37 cu ft more cargo space than similar trucks with conventional leaf springs, according to General Motors. Other advantages are: less rigid and less expensive crates and containers can be

used because road shock will be cushioned; eliminates spring and other vibration noises; simplifies loading and unloading because floor is kept at a constant height; spring lubrication not necessary and maintenance reduced; and, if necessary, air spring pressure can be adjusted to throw more load weight on the driving axle.

Transistors Made Easier

The development of a new method of manufacturing transistors and other solid state devices made from germanium has resulted in two improved types of transistors: (1) one capable of efficient operation at very high frequencies; and (2) a special type called a photodiode which is 10,000 times more sensitive to light than a conventional photo-electric cell, yet can control a hundred times more current. The transistors are the p-n-p germanium junction-type.

Conventional methods of making transistors rely on precise temperature control to get consistent quality in the product. A thin slice of n-type germanium is placed between two layers of metal and heated. The metal atoms dissolve through the germanium, forming two outside layers of p-type germanium and leaving a thin n-type layer between them. The thinner and more uniform the n-layer, the better the performance of the finished transistor. Too high a temperature causes the thin layer of n-type germanium to melt away, and the transistor is worthless. Too low a temperature leaves the n-layer thick, giving poor transistor performance.

Westinghouse claims that its new process permits the temperature to be practically uncontrolled, producing a more consistent quality from one transistor to the next. Key to their new process is a "cooling off" period during the heating of the transistor. The process allows the critical n-layer to build up to the desired thickness and uniformity.

The transistors can amplify electrical pulsations many times higher in frequency than those handled by the conventional junction-type transistor. The new photodiode operates on a voltage from a 1½ v dry cell, or a 6 v storage battery, yet operates a standard relay without amplification.

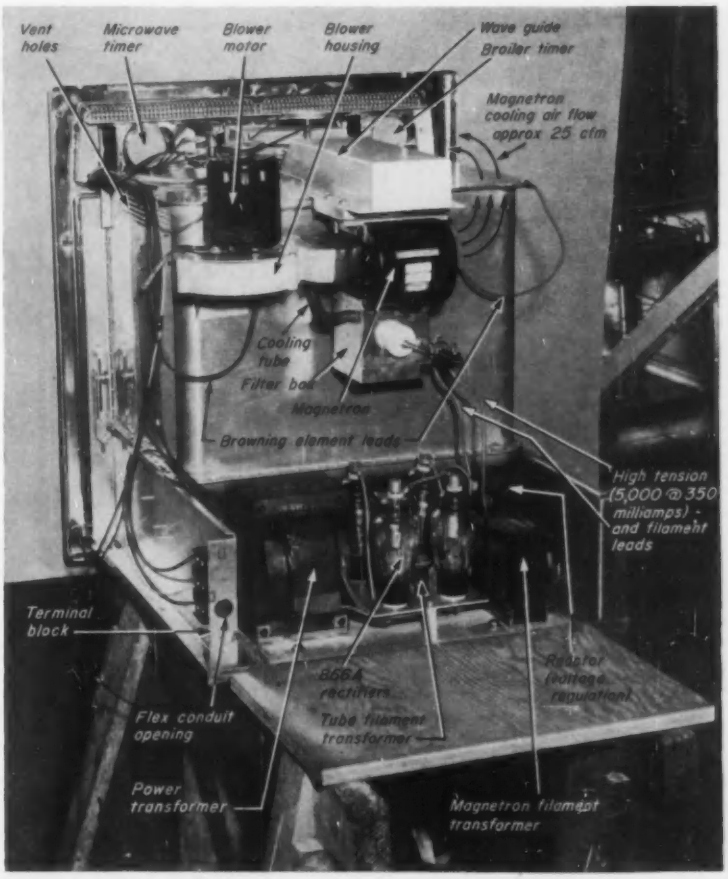
Short Wave Cooking

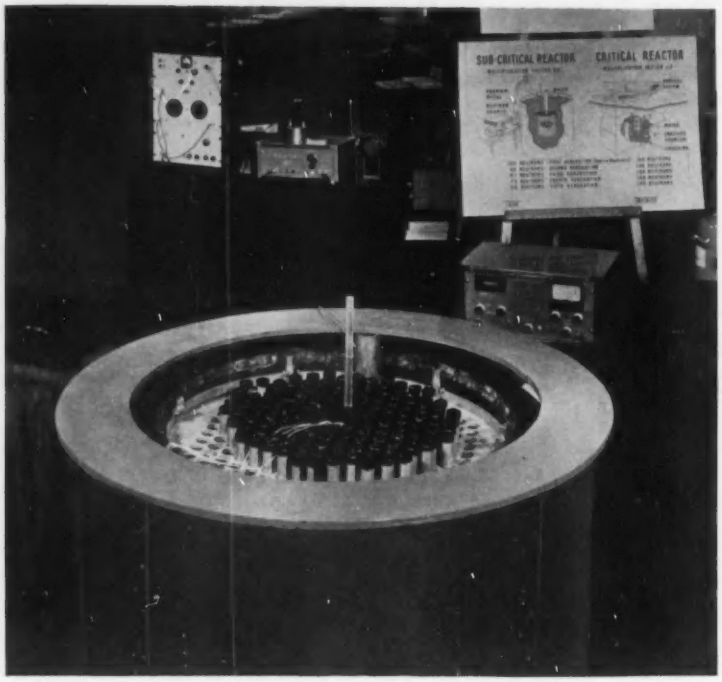
The rear view of Tappan Stove Company's new electronic range, marking the beginning of an era of high speed home cooking. Operating on 60 cycle, 220 volts a-c, this is converted to negative d-c voltage pulsating from zero to minus 4800 v 120 times per second. Applied to the cathode of a type QK-390 magnetron cooking tube with a grounded anode results in the generation of microwave power at 2450 megacycles per second. Because of this, the Federal Communications Commission licensed the unit this wavelength on which to cook.

The microwave unit was developed in conjunction with Raytheon Mfg. Co., with the built-in model weighing 150 pounds. The oven interior is 18 in. wide, 14 in. deep, 11 in. high, and is aluminum lined. On top, inside, is a high speed electric unit which can be used for browning meats. The oven will not operate unless the door is closed, making it impossible to come in contact with the microwaves. Neither the oven nor the dish containing the food becomes hot during the cooking process, because the oven reflects the microwaves, and the dish transmits them. Only the food absorbs the microwaves and becomes heated.

Temperature controls are not needed. The high or low speed is selected, and the timer is set. The range shuts off automatically when cooking is completed. The timer is calibrated in seconds for the first three minutes. Examples of cooking time: a 5 lb roast in 30 minutes; baked potatoe in 5 min; broiled bacon on a paper plate in 2 min; and bake a 2-layer cake in 6 minutes.

The manufacturer Tappen Stove Co., of Mansfield, Ohio, claims that the cost of operation is less than that of a conventional electric range. Retail price of the new unit: $1000.





Sub-Critical, "Pickle-Barrel" Reactor for Educational Use

A popular booth at the recent Nuclear Engineering and Science Congress and Atomic Exposition in Cleveland was that of the New York University College of Engineering. On display, and in operation, was their "Pickle-Barrel" (actually in a 5 ft deep pickle barrel) Sub-Critical Reactor (see illustration). Allocation of fissionable material by the Atomic Energy Commission was the first for an educational purpose. (All other fissionable materials were allocated for research). The unit, which is presently located at the University Heights campus of NYU is a laboratory device for students in the nuclear engineering program leading to a Masters Degree.

The barrel is filled with ordinary tap water, two tons of uranium metal rods (black-capped in illustration), a neutron source of radium-berrylium, and measuring equipment including Geiger counters.

The assembly is sub-critical because it cannot sustain a full nuclear chain reaction. It does permit a production of neutrons up to 100-million per second. For each neutron from the source, 8 to 10 neutrons will be generated from the uranium by the quenched chain reaction. The reactor operates at 1/300 of a watt, compared to nuclear power plants giving off millions of watts. Because it is subcritical, the reactor is safe at all times and needs no expensive shielding or heat removal equipment.

In the early 1940's, experiments with units such as this preceded the first nuclear chain reaction. Such assemblies are still used in AEC installations for quick pilot tests of features of much larger operating nuclear apparatus. One test would be to determine the proper quantity of material and the best geometrical arrangement of the components in a reactor for a nuclear-powered aircraft.

Among the laboratory exercises possible with the unit at NYU are: neutron measurements; experimental observation of individual component features of chain reactions; foil irradiations; and the study of fission and the products of fission.

The installation proves that a university can, at minimum expense (not more than a few thousand dollars), plus the loan of uranium metal and a neutron source from the AEC, provide a laboratory for students interested in nuclear engineering. At present prices, the uranium is valued at about $80,000.

Dispute at Lockheed Causes Missile Scientists Walkout

The big question of who should have control of Lockheed Aircraft's missile program—the research scientists or the management-level aeronautical engineers—has resulted in the mass resignation of top echelon research scientists at that company. Dr. Ernst Krause, director of the research laboratories branch of the company's missile systems division, was the first to leave. He was followed shortly thereafter by 15 of his immediate subordinates.

Key positions vacated were: director of the nuclear physics lab; director of the computer and controls lab; director of the physics and chemistry lab; and head of the systems laboratory. The remaining 8 to 10 per cent of research force which resigned consisted of sub-section chiefs and other supporting personnel.

The research scientists claim that in such a complex field as missile development, they should be in control of the project from the beginning. It is important, therefore, that the scientists be part of the policy-setting body coordinating design and production activities from the beginning to the end of the project.

Lockheed's engineering staff says that there comes a time when the scientists should give up their projects to the engineers and manufacturers and start on a new project. Or, putting it bluntly, scientists should be satisfied with being scientists, and should not attempt to be managers.

The walkout started when Lt. Gen. Elwood Quesada, V.P. and general manager of the missiles division, resigned. It was reported that this same policy disagreement was responsible for his resignation. One story is that originally the company had planned to set up the missiles program under scientist control. However, pressure from other groups developed, and policies were changed so that con-

trol of the projects drifted out of the hands of the scientists.

One of the scientists said that his group had been relegated to the role of stepping in and rescuing the engineers when the engineers' incorrect approach to missile problems got them in trouble.

Lockheed management says that there is no hope of a reconciliation and return of the group, but that the company's research program will not be affected by the walkout. Lockheed personnel have been promoted to fill the gaps, and scientists have been brought into the company to fill other key spots. Dr. Louis Ridenour, of the Naval Research Lab., has taken the post left by Dr. Krause.

Dr. Krause said that he and some of his resigning associates have set up a consulting firm in the Los Angeles area, working on government and industry missile problems.

"Necking Down" of Metal Test Sample Automatically Followed

The standard test given to a metal sample about ½ in. in dia and 5 in. long has been to place it in the jaws of tension tester and stretch it to the breaking point. The information gained is the force exerted at the breaking point, and the total elongation before breaking.

Metallurgists at Westinghouse Electric Corp., 401 Liberty Ave., Pittsburgh 30, Pa., are getting a clearer picture of the behavior of metals by plotting true stress-strain curves for the material in tension, basing the measurements on the changing dimensions. This is not done by stopping the test at various points to measure the diameter, but rather with a special device which clamps around the test specimen and automatically follows the "necking down" to the breaking point.

According to Westinghouse, the information obtained with this device can be used not only to determine the effects of heat treatment, chemical composition, and mechanical working, but to predict the behavior of the material under more complex states of stress like those in combined stress tests and forming operations.

Metal Notes . . . .

Magnesium. The results of a two year experiment with cathodic protection on the hull of a U. S. Naval destroyer have shown the system to be 100 per cent effective in preventing underwater hull corrosion. The magnesium-anode cathodic protection system also proved 90 per cent effective in eliminating corrosion of rudders, shafts, and struts. Of particular importance is the reduction of corrosion in sea chests and other hull openings. Current for the system was furnished by 20 large magnesium anodes, 10 on each bilge keel. A supplemental system using an impressed-current graphite anode was used, but was not too effective because of excess current flow to areas adjacent to the electrode.

Zirconium. Enamels developed at Battelle Memorial Institute, Columbus, Ohio, and applied to zirconium, are protecting that metal from oxidation in air at 1110 F for 1000 hr. In 100 hr tests with liquid lead at 650 F, and liquid bismuth at 1110 F, the enamels protected the zirconium, a metal used in the fabrication of nuclear reactor cores. However, the enamels did not give the zirconium good protection against high temperature water, and liquid potassium at 650 F attacked the enamels rapidly. The enamels were developed from frits based on the lead silicate glass system.

Beryllium Oxide Powders. Another project at Battelle showed that high-purity beryllium oxide shapes can be fabricated by the usual ceramic processing methods. Easily sinterable powders were prepared from high purity-sulfates or hydroxides of beryllium by thermal decomposition under highly controlled conditions. Dense, strong compacts were made. Beryllium oxide is of interest to reactor designers because it combines resistance to high temperatures in oxidizing atmospheres with more efficient moderating power than most other materials. Also, it has a high thermal conductivity, close to that of iron.

Titanium. Industry review for 1955 shows the dollar value of mill products to be about $60-million, with sales of sponge metal adding $30-million. For 1956 these same two figures will be $120-million and $40-million respectively. Mill products totalled 1900 tons—about 54 per cent of this sheet and strip, and the rest bar, billet and extrusions. Present government estimates place 1956 requirements for titanium mill products from 4000 to 4500 tons.

Cobalt. After more than a year of experimentation, cobalt is being taken successfully from cobalt-copper ore mined in Idaho. The process is a chemical one developed by the Chemical Construction Co., subsidiary of American Cyanamid Company.

Automobiles Get More Aluminum

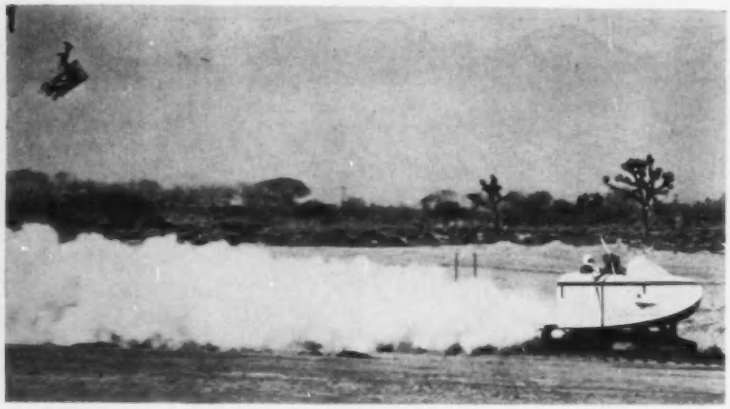
According to a report just released by the Aluminum Company of America, the average 1956 model passenger car used 18 per cent more aluminum than did the 1955 model, or, an increase from 29.6 lb. to 35.2 pounds. This adds up to 246-million pounds used by the automobile industry, if 7-million cars are produced.

The report shows that almost 50 per cent of the aluminum used in the cars goes into the automatic transmissions. The engine takes 30 per cent, and body trim 7 per cent. The balance goes into wiring, brakes, power steering and air conditioning units.

Some of the reasons for this increase are the trend towards more v-8 engines, which use more of the metal than the 6-cylinder models, and General Motor's new automatic transmission design which required an additional 14 pounds. In trim, a number of the 1956 models use large aluminum die castings in grille components. An upholstering fabric uses 0.8 lb. of aluminum thread.

Predicted uses for aluminum in automobiles are: aluminum radiator fins joined to brass tubing; eventually all-aluminum radiators; brake drums and differential housings. Doehler-Jarvis Div. of National Lead has an experimental production line for aluminum die cast engine blocks.

WINDBLAST CAUSES THE DUMMY'S limbs to be forced off the arm and leg rests of the seat and flail around.



LESS THAN ½ SEC AFTER EJECTION from the test sled, the dummy has rocked backward and faces in the opposite direction. Telemetered data from instruments in the dummy's head showed that at this point it began to rotate back.

ROCKING MOTION ROLLS DUMMY around to upright position after it has spun sideways 180 deg. To record the accelerative and decelerative G forces during the tumbling and sudden decrease in velocity, six accelerometers were used to measure forces vertically, horizontally and laterally at both head and stomach.

TWO SECONDS AFTER LEAVING THE SLED, the dummy appears to be flying. At this point, just before hitting the ground dummy has slowed down to approximately 250 mph.

Supersonic Bailout Effects Duplicated

Recently, newspapers carried an account of the experience of test pilot George Smith when he bailed out of a North American F-100 Super Sabre at a speed of 777 mph (Mach 1.05) at 6500 ft altitude. The resulting injuries put him in a hospital for six months.

Recently at Edwards Air Force Base in the Mojave Desert, tests were made on a combination steel and rubber dummy to duplicate in every respect the bailout of test pilot Smith. Shown here are pictures of the dummy, loaded with telemetering equipment, being ejected from the cockpit of a rocket powered sled traveling faster than sound. The dummy matched Smith's size, weight, and the clothes he wore on that day. The joints were tightened, and measured to duplicate the muscular resistance of a man of Smith's size and strength.

From the time the dummy was ejected from the sled until it hit the ground, data was transmitted constantly to recording devices in a building next to the center of the track. Movements and forces were recorded in increments of a thousandth of a second, and reserved on charts and graphs for North American's future use.

One of the theories which was corroborated by the tests was that the pilot performs a series of violent rocking motions rather than complete revolutions of tumbling when he hits the air stream, and while he is still in the ejection seat. It is these violent changes of direction that result in the many hemorrhages caused by heavy blood. The wild flailing of the arms and legs is easily capable of snapping the bones or pulling them out of their sockets.

The pilot is also subjected to yawing motion that cause him to rotate sideways a full 180 deg and back within the first two seconds after the ejection. Rapid rolling motions further complicate the data and computations.

Much of the data has not been reduced to a workable form, but the knowledge should lead to the development of more protective equipment for flying—and bailing out of—planes traveling at high speeds.

GM's Firebird II Points to Car of Future

Introduced at General Motor's Motorama in New York last month was their family-type, four passenger gas turbine car for highway use. Called the Firebird II, the car is regarded as one of their "dream cars" and will not be produced. However, the engine and many of the unusual features on the car will be automotive news from now on.

Engine. The stumbling block for the use of gas turbines in cars has been the hot exhaust gases. In the new engine, a regenerator is used which recaptures 80 per cent of the exhaust heat for use, and brings the fuel economy up to that of a piston engine. The regenerator is nothing more than a metal mesh drum rotating at 20-30 rpm through the hot exhaust gases and then through the cool compressor discharge air, carrying the heat from the exhaust to the incoming air.

Turbine Blades. There will be a concentrated effort by all automobile companies and others interested in the field, to get the cost of turbine blades down to a point where the entire turbine can be sold for $20.00. The automobile industry claims that a turbine engine must be available for about $200-300, as against a present cost of $15,000.

Brakes. Made by the Moraine Products Div., the brake operates by squeezing a rotating cast iron disk between pads of metal lining material. The iron disk rotates with the car wheel, and when pressure is applied, the disk is squeezed between movable pads of metal lining materials on the inboard side and fixed pads on the outboard side. The cast iron disk has an air space between the braking surfaces, with blades that pump air centrifugally through the disk while it is spinning, thus dissipating the heat generated by the braking action.

With many 1957 models using a 14 in. wheel, as opposed to the current 15 in. wheel, the new all-metal brake seems applicable.

Electrical System. An a-c generator for the charging system with a delivery of almost 100 amp (its rated output) at idle speed. The generator is smaller than a similar d-c unit. Since the output is three-phase a-c, the charging system uses a rectifier to produce the d-c for the car's 12 v battery. A new transistor voltage regulator is used.

Shifting is done by a two-step solenoid, since the transmission is located back between the rear wheels. With the shift selector in "drive" position, one part of the solenoid coil is energized and a plunger moves part way in. In "reverse" the remainder of the coil is energized and the plunger moves all the way into the coil. Mechanical linkage performs the shifting. When the car is parked, the drive shaft is locked by an electrically operated pawl that engages a gear on the shaft.

Suspension. Individual wheel suspension is combined with oil-air units. Each rear wheel is mounted on a short stub axle suspended from the frame by a swing arm. All pivot points are permanently lubricated and use plastic bearing surfaces supplemented by rubber cushions at rear suspension points to reduce the noise between the suspension and the body.

Transmission. A four-speed planetary gear and fluid coupling with an idle cutout that allows the power turbine to drive accessories in the rear without driving the rear wheels. The transmission is set on the frame between the rear wheels and drives each wheel by a double universal joint driveshaft. The driveshaft runs in a sealed tunnel that acts as a central structural member.

Hydraulic System. A single source supplies power for steering, brakes, air-hydraulic suspension system, windshield wipers, seat adjustments, and others—indicating the role of hydraulics in future cars. Hydraulic power is drawn from two accumulators. When the system pressure drops to 850 psi, a pump automatically cuts in to recharge the accumulators to 1000 psi. When the ignition is shut off, electric check valves close to maintain accumulator pressure.

Individual motors, powered by the accumulators, drive the windshield wipers, and do away with the mechanical linkage. The unit has an automatic alternating power application to free frozen wiper blades.

Body Shell. Made of titanium.

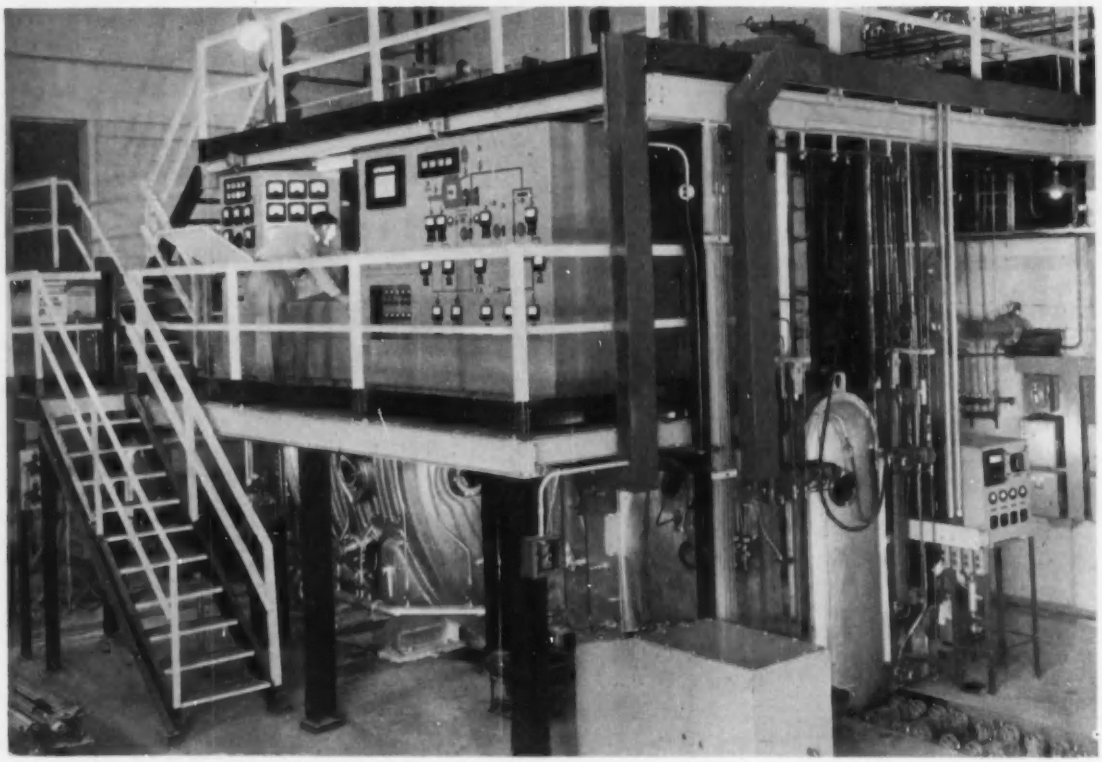
Briefs

Permanent and dry lubrication with a process called Useco-lube is possible on all metallic surfaces. Made by the U. S. Engineering Co., 14550 Lesure Ave., Detroit, Mich., the method is said to be most beneficial where ordinary oils and greases are not feasible. The process impregnates and film coats any metallic surface and leaves no surface build-up. Oxidation, corrosion, and friction is reduced and sticking is prevented. Effective lubrication is produced at temperatures ranging from −30 to 800 F.

Miniature Precision Bearings, Inc., of Keene, New Hampshire, and the Mechanical Engineering Dept., of the University of New Hampshire, have completed a series of computations using standardized methods for evaluating basic dynamic capacity (bearing constant C) of bearings in the miniature range—$\frac{1}{4}$ in. OD and smaller. The results are reported to show that the capacities which have been used in industry are, to certain degrees, higher than the actual values. The calculations extend the methods adopted by the Anti-Friction Bearing Mfgrs. Association's Committee on Load Ratings to miniature bearings. Ways to calculate dynamic capacities for miniature thrust, flat face thrust, and pivot bearings are available.

A new fluorocarbon plastic laminate with high temperature (400 F) and good chemical resistance can be adhesive bonded to almost any contoured surface. The laminate, a 10-12 mil continuous layer of Kel-F plastic on glass cloth, is being produced by the Garlock Packing Co., Palmyra, N. Y., and the U.S. Gasket Co., Camden, N. J. The laminate comes in sheets 36 in. by 46 in., with longer sheets 36 in. wide on special order. The sheets can be hot or cold formed; have low temperature flexibility; low permeability to moisture and inorganic liquids; and high impact resistance.

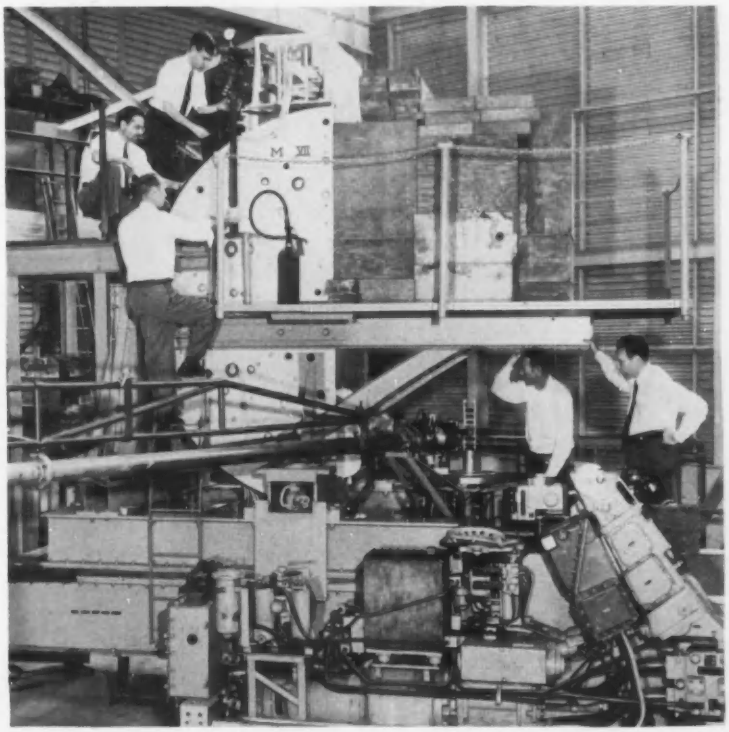
THE NEWS IN PICTURES



JUST PLACED IN OPERATION at the Vacuum Metals Corp., Syracuse, N. Y., was this 2200 lb vacuum melting furnace, the largest in the country. Previous furnaces had a capacity of 300 and 600 pounds. The new furnace is remotely operated by the melter, who from one console can control the charging, mold transfer, and pouring operations. The melting unit is a liquid cooled stainless steel chamber, wth connecting air lock chambers for charging raw materials and discharging ingots. With this arrangement, it is possible to charge, melt, pour and remove ingots without affecting the vacuum in the melting chamber. In addition, the mold handling mechanism permits the casting of ingots of varying size and shape, singly or in multiples, from a single heat. The furnace was designed and built by the National Research Corporation.

BETTER TELEVISION RECEPTION, particularly in hilly or mountainous terrain, will be possible as a result of General Electric's new "high-channel" broadcast antenna. Designed to operate under the highest power ever fed into a television transmitting antenna, the VHF single-bay helical antenna transmits broader beams than do the "bat-wing" antennas now in use. The most powerful VHF television stations now in operation transmit at 50,000 watts. The new antenna will allow this to be increased up to 100,000 watts. Advantage of the antenna is its simplified design. It has only three feed points, compared to 16 needed for a comparable "bat-wing" type antenna.

A DOUBLE-DUTY GYROSCOPE developed at Westinghouse Electric's Research Labs uses an unusual mounting arrangement to provide in one unit both rate and integrated-rate response. This gyroscope consists of a canned gyro wheel in an enclosed, fluid filled case. The gyro wheel is supported from a concentric sleeve by cross springs which give rate-calibrating restraint about the precession axis. The sleeve is supported on ball bearings, and the viscous, thin section of fluid between the bearings and the case provides the damping restraint about the precession axis required for the integrated-rate response. Thus, the displacement of the gyro wheel about its precession axis is a measure of the sum of input angle and angular rate in a ratio fixed by the relative magnitude of restraint of both the viscous and compliant components. These may be designed for optimum performance requirements of a particular control system.



WHAT IS IT? The 55-ton, 16 ft high "thing" shown here is a nuclear microscope at the High Energy Physics Lab., Stanford Univ., Stanford, Calif. The instrument is used to examine the particles within an atom's nucleus, and measures within an accuracy of four thousandths of a trillionth of an inch—yet it does not allow the user to see the nuclear particles. The piece being examined here is a gold foil mounted in the ladder-like frame at the end of the pipe. Stanford reports that the microscope is revealing more information about the atom's core than has ever been known. Where an electron microscope shoots electrons of 50,000 to 100,000 volts through its target, the nuclear microscope increases this to 550,000,000 volt electrons. This is supplied through the long pipe at left which leads to a 220 ft electron linear accelerator. The microscope here differs from an electron microscope in that in an electron microscope electrons are picked up on a photographic plate after they have passed through the target. This plate is then developed. The Stanford microscope picks up the electrons, after they have penetrated the target, in a 200,000 w magnetic spectrometer where it counts them, and measures their energy losses, and deflection angles. Such data is better than a photograph.

Helicopters Are Getting Larger

Now undergoing test flights for the U. S. Air Force are the two largest helicopters ever built. One is Piasecki's 40 passenger YH-16A Turbo Transporter (above), and the other the XH-17 built by the Aircraft Div., of Hughes Tool Co. (below).

Piasecki's YH-16A is powered by two Allison XT38 turbo-prop engines, which drive two 82 ft dia rotors. The YH-16A weighs 16 tons, and will carry 40 troops at a top speed of 150 mph. The new ship is part of military program to develop a 5-7 ton capacity cargo for troop carrying helicopters, and is replacing the older piston powered YH-16. YH-16B, a production model of the YH-16A, will carry 69 troops.

A reduction gear box with a 5:1 ratio reduces the 14,300 rpm to 2800, and permits use of the transmission designed for the piston-engine version. Fuselage length is 77½ feet.

The pressure-jet, single rotor XH-17 developed by Hughes is of radically different design, and actually is a ground test stand converted into a flyable test stand to get additional data for future pressure-jet helicopters. In operation, the gas turbines mounted on the side of the fuselage send hot gases through ducting up to the rotor blades, and out to five burners at each blade tip. The rotor measures 130 ft from tip to tip.

Helicopters of this design are mounted on stilt-like legs so that the cargo is first straddled, picked up, and held in place with adjustable lift mechanisms. Typical loads would be a 2½ ton truck, a bulldozer with blade, a pod with 75 combat troops, a 155 mm howitzer, or a bridge.

Hughes expects helicopters of this design to carry loads of more than 10 tons. In recent tests top speeds of 70 mph were attained at a gross weight of 46,000 lb.

COMING EVENTS

FEB. 7-9

11th Annual SPI Reinforced Plastics Div. Conference, Hotel Chalfonte-Haddon Hall, Atlantic City. N. J. Subject of symposium to be Fatigue and Creep-Rupture of Reinforced Plastics. The symposium will bring together speakers with the latest information, pointing up areas needing further investigation. Authors submitting papers should submit abstracts to C. R. Stock, American Cyanamid Co., Stamford, Conn.

FEB. 16-17

AIEE-IRE-University of Pennsylvania Transistor Circuit Conference, University of Penn., Philadelphia, Pa.

FEB. 16-17

Drop Forging Association, Winter Industry Meeting, Park Sheraton Hotel, New York, N. Y. Theme will be "Prosperity and Profits."

FEB. 27-29

American Management Association, Annual Electronics Conference and Exhibit, Hotel Commodore, New York, N. Y. The conference program will stress two major aspects of the business applications of electronic equipment: methods of determining the feasibility of using large, small, or medium size electronic computers; and the experience of firms who have used them.

MARCH 12-16

12th Annual Corrosion Conference of the National Society of Corrosion Engineers, Hotel Statler, New York, N. Y. There will be a variety of discussions on: corrosion principles; chemical inhibitors; steel metallurgy; power and communications; high temperature corrosion; plastics; protective coatings; and instrumentation.

MARCH 14-16

Conference, Aviation Div., of the American Society of Mech. Engineers, Hotel Statler, Los Angeles, Calif.

MARCH 14-16

Pressed Metal Institute, Annual Spring Technical Meeting, Hotel Carter, Cleveland, Ohio. For further information, write to H. A. Daschner, Managing Dir. Pressed Metal Institute, 3673 Lee Rd., Cleveland 20, O.

MARCH 19-21

ASME, Spring Meeting, Multnomah Hotel, Portland, Ore.

MARCH 19-23

Tool Show, 24th Annual Convention of the American Society of Tool Engineers, International Ampitheatre, Chicago, Ill. Based on reports from over 70 per cent of the exhibitors, more than 28,000 items will be on display. "Tooling for Tomorrow" theme of show.

MARCH 26-27

Instruments & Regulators Div., of ASME, Conference, Princeton University, Princeton, N. J.

MARCH 26-28

Society of the Plastics Industry, 13th Annual Conference, Pacific Coast Section, St. Francis Hotel, San Francisco, Calif. Some of the papers to be presented: Applications of Honeycomb Structures in Aircraft & Missiles; Reinforced Plastic in Aircraft Armament; Reinforced Plastics in Missiles; Evaluation of New Finishes on Glass at Elevated Temperatures; New Materials; Reinforced Fibers; and others.

APRIL 10-12

12th Annual Meeting of the Metal Powder Association, and the 1956 Metal Powder Show, Hotel Cleveland, Cleveland, Ohio. The meeting will cover structural parts, self-lubricating bearings, filters, friction materials, iron powder electronic cores, and others. The latest developments in press, furnaces and equipment will be shown.

APRIL 17-18

1956 Westinghouse Machine Tool Forum, Buffalo, N. Y.

APRIL 18-20

National Industrial Research Conference, sponsored by the Armour Research Foundation as part of their 20th anniversary, Illinois Institute of Technology, 35 West 33rd St., Chicago 16, Ill. Twelve papers will be presented, with a number of industrialists and research directors taking part in a program designed to guide industry in the administration of more profitable research.

APRIL 19-20

Environmental Equipment, Science Section, Second Annual Meeting, Sheraton Hotel, Chicago, Ill. More information may be obtained by writing to Mr. H. F. Sander, Vapor Heating Corp., 6420 W. Howard St., Chicago, Ill.

MAY 3-9

60th American Foundrymen's Society Casting Congress and Show, Convention Hall, Atlantic City, N. J. A technical-practical program will feature over 60 sessions and shop courses, dealing with the production aspects of cast metals, from raw material stage to delivered products.

MAY 9-11

4th Welding Show, sponsored by the American Welding Society, Memorial Auditorium, Buffalo, N. Y. One-hundred companies will exhibit. Twenty-one technical sessions with about 50 speakers are planned. The Metals Engineering Div., of the ASME, will join in four sessions, and the welding committee of the Atomic Energy Committee in one session.

MAY 14-17

First Design Engineering Show, Convention Hall, Philadelphia, Pa. The first show of its kind, it will be devoted to, and will have on exhibit, all types of original equipment which go into the manufacture of a finished product. The show is an outgrowth of another show called The Basic Materials Show.

MAY 16-18

Society for Experimental Stress Analysis, Spring Meeting, William Penn Hotel, Pittsburgh, Pa.

MAY 27-31

National Fluid Power Association, Spring Meeting, at the Greenbrier Hotel, White Sulphur Springs, West Virginia.

Business Investment Holds Key To Both Growth and Stability

What federal tax policy will best promote both growth and stability in the American economy? The Joint Economic Committee of Congress has been asking this crucially important question in public hearings. This editorial suggests one vital part of the answer.

The proposition advanced here is that—

> Tax policy must encourage a continuing high level of business investment in new plant and equipment, because such investment makes a special contribution to *both* economic growth and economic stability.

Growth Needed for Security

We must have both growth and stability.

A vigorous economic growth is essential to our national security. As Congressman Wilbur D. Mills said in launching the Joint Committee's hearings, "The present complexion of world affairs places a premium upon strength and growth in our national economy." Growth is likewise a major ingredient of a healthy domestic economy. Growing enterprises and growing communities offer far more opportunities for satisfying careers than those which are not growing.

A reasonably stable economy, without violent ups and downs, is also essential to our national welfare. Extravagant booms and their more or less inevitable result, severe depressions, waste labor and resources and cause great human misery. Both major political parties have accepted the obligation imposed by the Employment Act of 1946, that the federal government work to maintain high and stable employment.

There is general agreement that **the key to economic growth is investment in new plant and equipment.** Growth depends decisively on new facilities to increase production, and also to produce new and better products in new and better ways. At the same time, new plant investment provides employment for the important, and well-paid, one-fourth of our industrial workers who manufacture and build new production facilities. So if the process of business investment is kept on an even keel, the result is not only growth but also stability in a substantial sector of our economy.

But authorities disagree on the possibility of maintaining a high level of business investment for any great length of time. Some fear that it will lead to an excess of producing capacity and the glutting of markets, with recession or depression not far behind.

The history of our country offers some basis for the fear that it is dangerous to maintain a very high level of business investment. There have been times when the economy has suffered under the weight of excess producing capacity. **This fear, however, has been made obsolete by the recent course of our economic history which, in its earlier phases, nourished the fear.**

The World Has Changed

Here are some of the major considerations, cited at the Joint Committee hearings, which support the conclusion that we not only *can have* a high level of business investment and economic stability but that we actually *need* a high level of such investment to assure stability.

(1) Over the next 20 years our population is expected to increase by about one-third. But most of the population increase will come in age groups younger or older than normal working ages, and people will probably work fewer hours per week. Thus hours worked are not expected to increase more than 15%. Consequently, we must have a relatively large increase in the amount of production equipment per worker if our standard of living is not to suffer. This means a high level of new investment.

(2) About half of our present business investment goes to replace worn-out equipment, rather than to expand capacity as was true during the early stages of our industrial development.

(3) Thanks largely to the impact of organized research—for which we as a nation now spend about $4 billion a year—a large share of capital investment now goes to provide new products and new processes, rather than to expand existing capacity.

These developments make it unlikely that we shall develop the burden of excess capacity that plagued the economy in earlier periods. **Moreover, most capital investment plans are now made on a long-range basis. Companies are building facilities to anticipate their needs for several years ahead.** This increase in long-range planning has reduced the disturbing effects of temporary shortages and excesses in producing capacity.

The record of recent years speaks for itself. Business spending for new plant and equipment in 1955 was over $29 billion. This continued the high level of investment that has been maintained for the past ten years—a decade remarkable for both impressive growth and gratifying stability. A McGraw-Hill survey of preliminary plans for 1956 indicates another year of increasing investment, and expanding business activity.

Tax policy, to be successful, must consider this impressive contribution of business investment to both growth and stability.

Of course, the level of investment depends on many factors other than federal tax policy. The degree of business confidence is important. So is the strength of consumer markets. So is the attitude of organized labor toward the use of more efficient machinery. But tax policy is a crucially important factor. And it is becoming more so with new developments in our changing economy. These developments indicate that tax policy **must be geared to foster a high level of business investment, if the dual objectives of economic growth and economic stability are surely to be attained.**

This message is one of a series prepared by the McGraw-Hill Department of Economics to help increase public knowledge and understanding of important nationwide developments that are of particular concern to the business and professional community served by our industrial and technical publications.

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Donald C. McGraw

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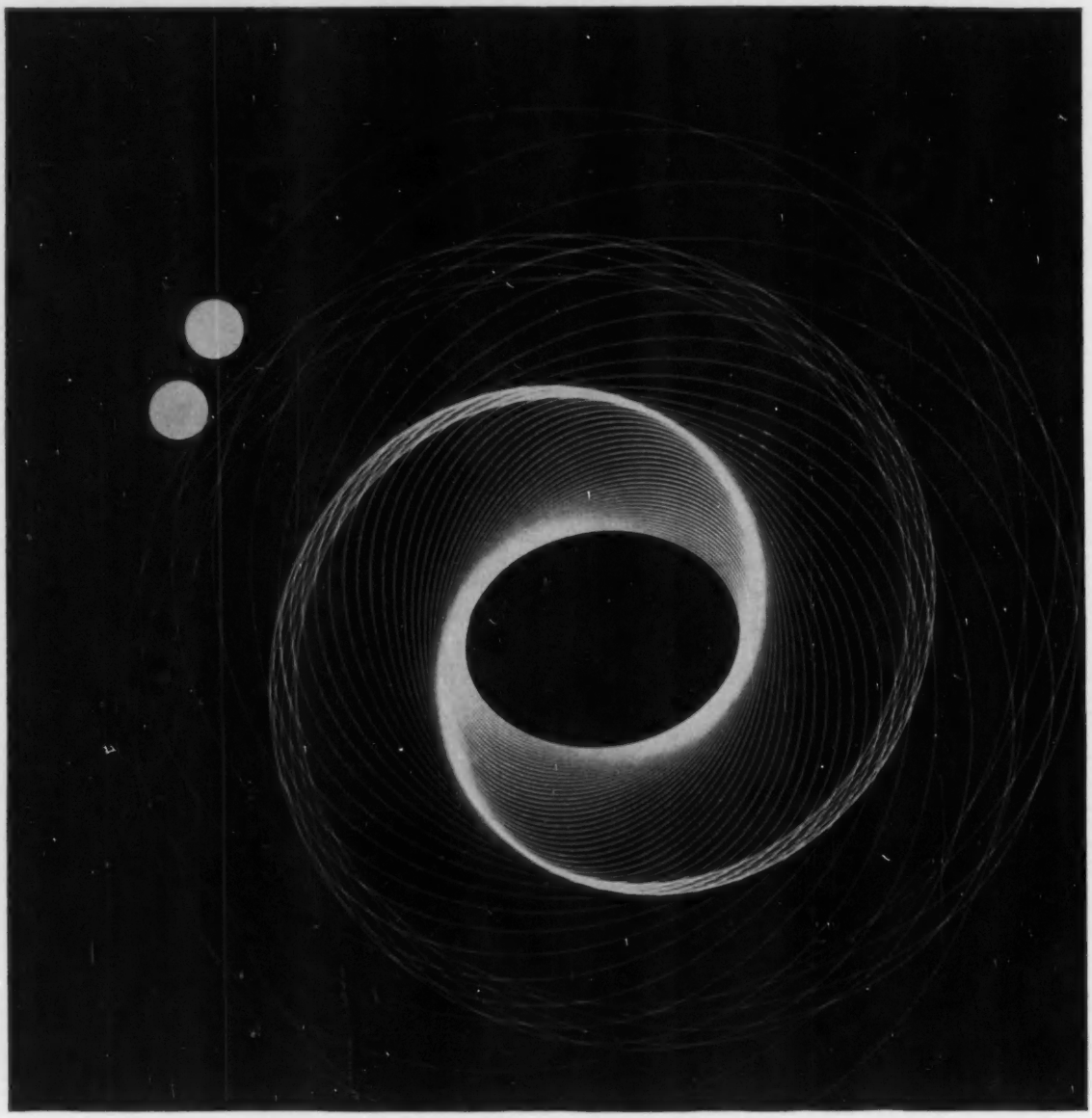

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Countersinks in Thin Plates

MARK LEVINE
Project Engineer, Grant Pulley & Hardware Corp.

PROBLEM IN COUNTERSINKING THIN PLATES for flat head screws and rivets is that the countersink may obliterate the clearance hole thus leaving a jagged edge. This is often missed by the designer who automatically calls for the standard size clearance hole as specified in Table I and illustrated in Fig. 1(A). Failure to spot this trouble causes the condition shown in (B). The shop may then be forced to redrill after countersinking to obtain a shoulder of at least 0.010 in.

With the aid of the charts on the following pages, a designer can quickly check dimensions and make the necessary corrections—including corrections for tolerance variations. The charts include typical countersink angles for screws and rivets.

Table I—Clearance Drills for Machine Screws

Screw Size		Close Fit		Loose Fit	
Screw Size	Decimal Equiv.	Drill Size	Decimal Equiv.	Drill Size	Decimal Equiv.
0	0.060	52	0.0635	50	0.0700
1	0.073	48	0.0760	46	0.0810
2	0.086	43	0.0890	41	0.0960
3	0.099	37	0.1040	35	0.1100
4	0.112	32	0.1160	1/8	0.1250
5	0.125	30	0.1285	29	0.1360
6	0.138	27	0.1440	25	0.1495
8	0.164	18	0.1695	16	0.1770
10	0.190	9	0.1960	7	0.2010
12	0.216	2	0.2210	1	0.2800
14	0.242	D	0.2460	F	0.2570
1/4	0.250	F	0.2570	H	0.2660

EXAMPLES:

A plate 0.093 thick is to be drilled and countersunk for a #8 flathead machine screw. Normally it is specified as shown in Fig. 1(A). However, referring to chart in Fig. 2 (Fig. 3 is an extension of Fig. 2) $A - B = 0.337 - 0.169 = 0.168$. Since $\theta = 82$ deg, $C = 0.096$ which would obliterate the clearance hole as shown in Fig. 1(B).

TWO SOLUTIONS ARE POSSIBLE:

1. **Keep countersink dimensions same.** To obtain a 0.010 in. shoulder C should be equal to $0.093 - 0.010 = 0.083$. From Fig. 12, $A - B = 0.144$. Therefore $B = 0.337 - 0.144 = 0.193$. Use a #10 (0.1935) clearance drill. This results in Fig. 1 (C) where bottom of screw head protrudes slightly.

2. **Keep clearance hole same.** This prevents bottom of screw head from protruding below plate which, if excessive, requires countersinking in mating plate. Since $A - B = 0.144$, $A = 0.144 + 0.169 = 0.313$. Countersink is changed to 0.313 dia. which results in Fig. 1 (D) where the screw head sits above the surface of plate.

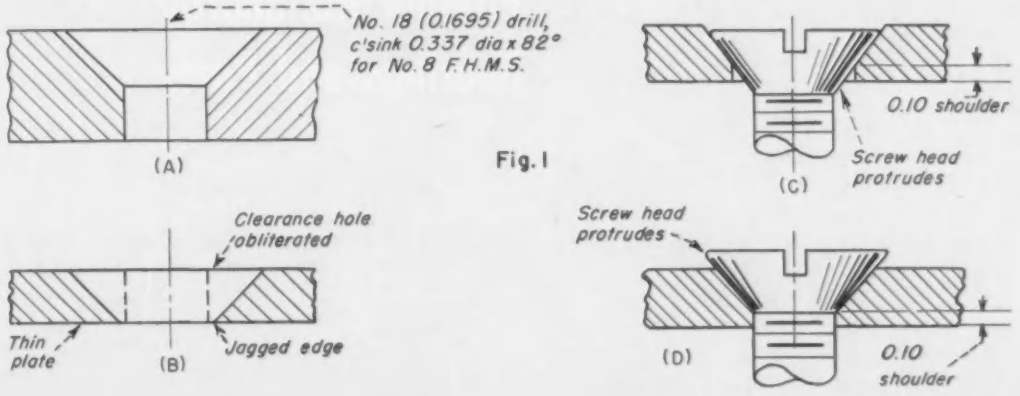
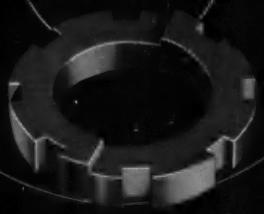


Fig. 1

(continued on page 221)

Not 25 not 50 not 75 but 100%



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skill and experience are
devoted to producing
the world's finest
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BOUND BROOK OIL-LESS BEARING CO., BOUND BROOK, N. J. EST. 1883

Countersinks in Thin Plates (continued from page 219)

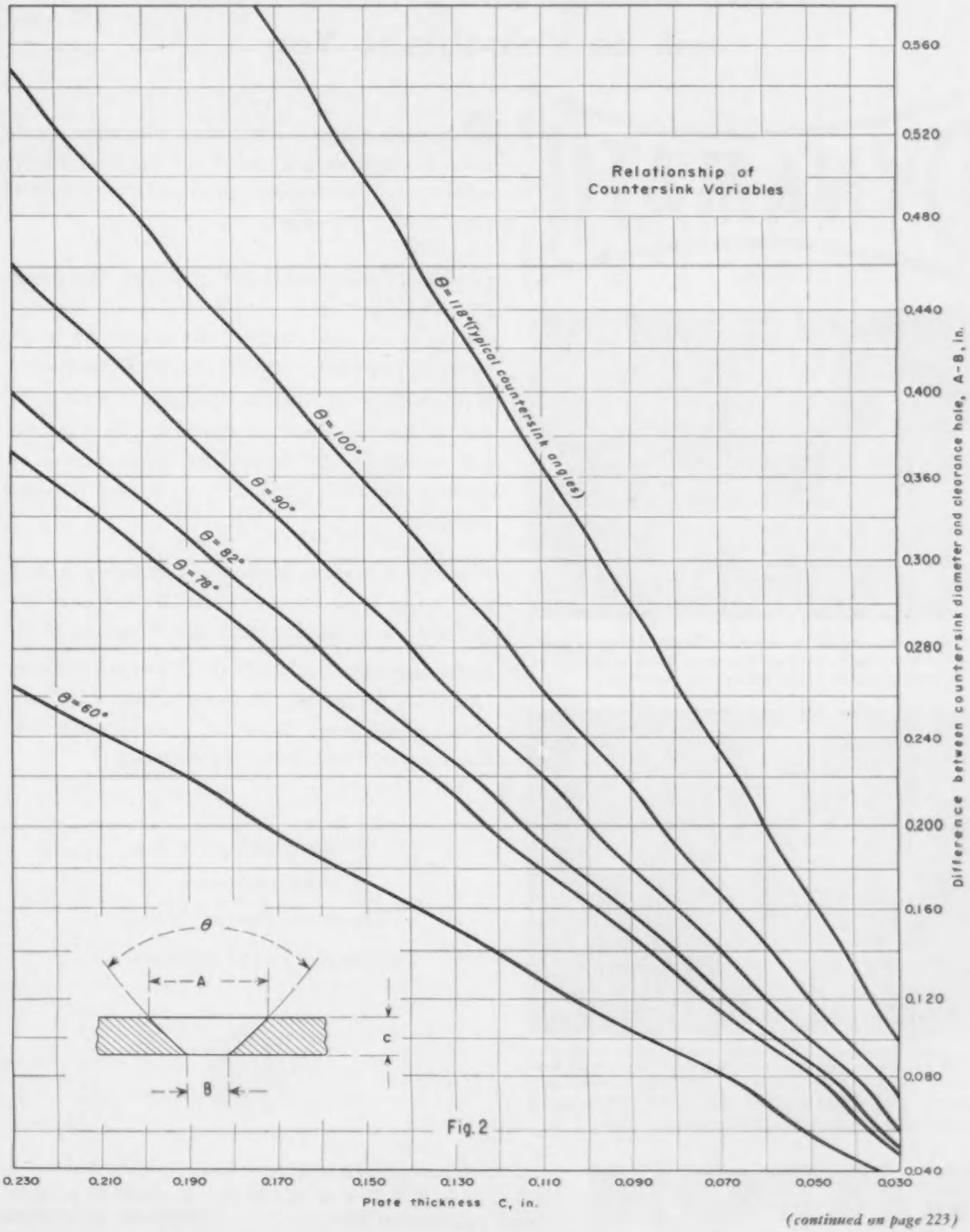


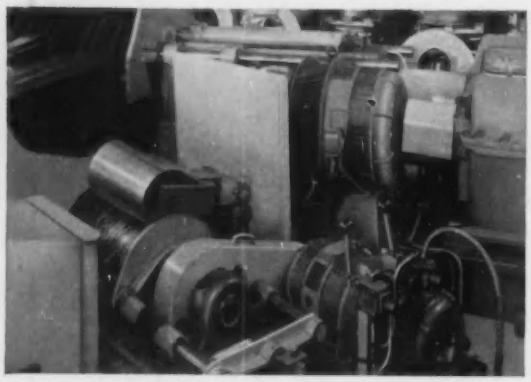
Fig. 2

(continued on page 223)

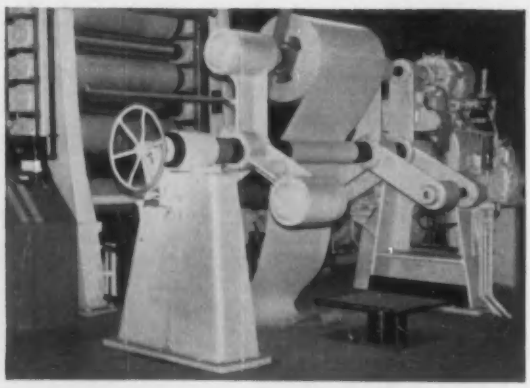
Tension Control Problems?

Dynamatic's Long Experience in Solving Industrial Windup and Unwind Problems will be Valuable to You

DYNAMATIC®



Metal slitter powered by Dynamatic Drives. Adjustable speed liquid cooled coupling used as main drive; Ajusto-Spede® Drives, with constant tension control, wind up the metal strips.



Completely Dynamatic driven paper super-calender. Adjustable speed liquid cooled couplings with Eddy-Current brakes drive the calender rolls and center rewinder. Dynamatic liquid cooled brake provides center unwind hold-back. Co-ordinated controls provide for wide-range adjustment of speed and tension.

Dynamatic Eddy-Current Drives with tension controls are used extensively in the fields of paper, rubber, textiles, ferrous and non-ferrous metals, plastics, and printing.

Combined with associated controls, Dynamatic Eddy-Current Drives provide automatic constant tension as the roll diameter changes on center rewinds and unwinds. Constant tension is maintained over a wide range of material delivery speeds without the use of dancer or follower rolls. Controls may be adjusted for tapered tension to increase or decrease tension automatically as the roll changes diameter.

Multi-range tension or tension adjustment over a wide range is easily accomplished at the operator's station to accommodate materials of various thicknesses or widths. Control modifications are available to provide for inertia compensation and other individual requirements. Dynamatic engineers are available for consultation on your problems.

Bulletins giving detailed information on Dynamatic Tension Control will be sent free at your request.

EATON

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DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 FOURTEENTH AVENUE · KENOSHA, WISCONSIN

Countersinks in Thin Plates (continued from page 221)

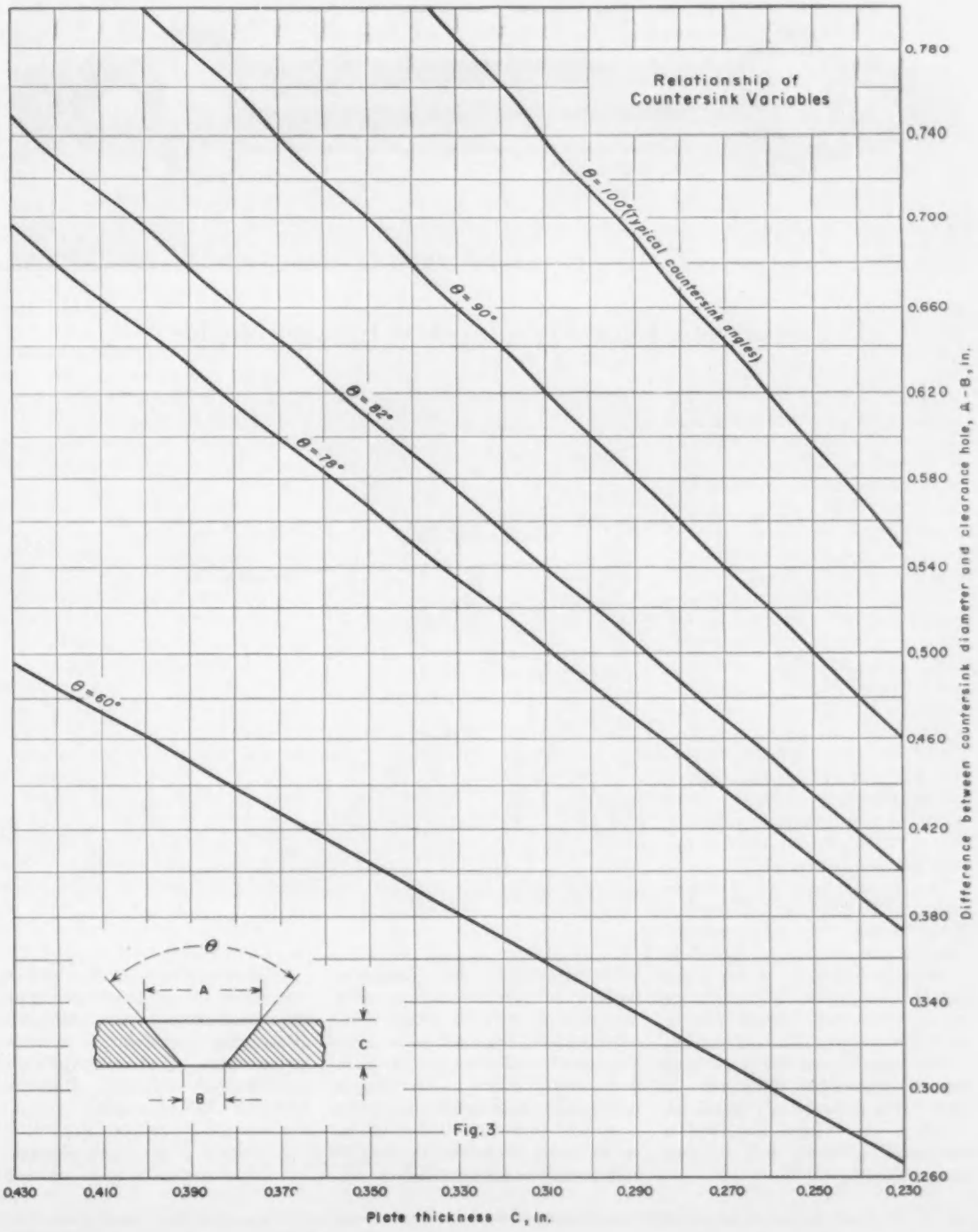
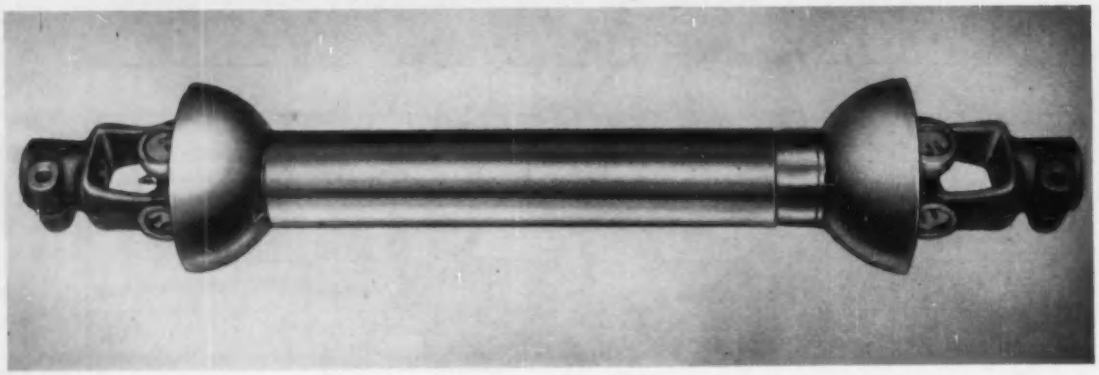


Fig. 3

NEW COMPONENTS

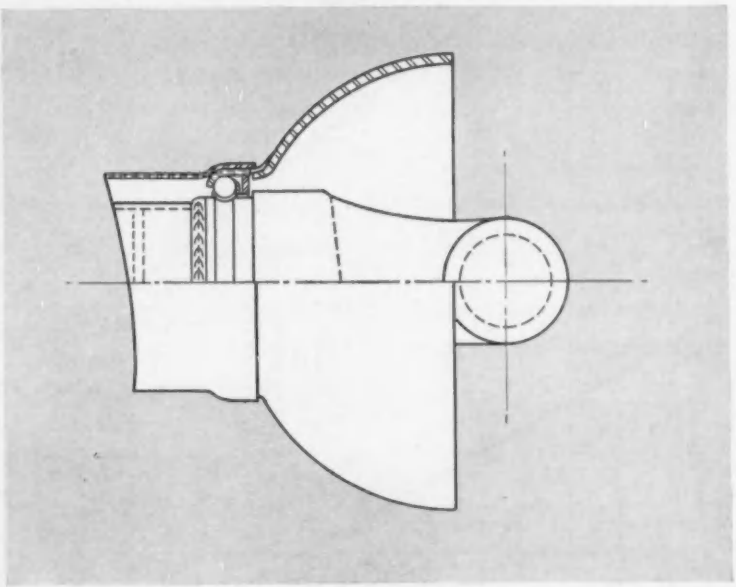


Shaft and Joint Assembly Has Integral Shield

Originally designed as a safety improvement for power take-offs in agricultural machinery, this jointed shaft has integral shields over the entire shaft-and-universal-joint assembly. The shields prevent farm equipment drivers and helpers from being ensnared and injured by exposed drive shafts. Besides safety applications, it is expected that the shielded shaft assembly will be useful in other power transmission systems requiring jointed shafts, especially where protection against abrasive chips or harmful contamination is necessary.

The shield's ball-bearing construction (at both ends) is easily serviced. The balls are contained in a cage in the bell-shaped end shields. Axial movement allows them to pass over the end of the hub and drop into the machined race for assembly.

The bearing races are induction hardened. To keep dust and grit out of the bearings, they are covered by a sealing ring which is held in place by three sheared tongs in the shield bell. To disassemble the unit, tongs are driven outward slightly with a punch and hammer. Bearing assembly is then removed, and the entire joint and shaft assembly slides out of shield. The tube-and-bell shield assembly is one integral unit, and is constructed of heavy wall, seamless steel tubing.



The new shielded shaft assembly is available in different models, with torque ratings of 350 to 10,000 in-lb, or from 3 to 60 hp, based on the rpm. The smaller assemblies, (350 in-lb torque rating) take up 3¾ in. This is the diameter of the bell housing. This dimension increases as the joints go up in rating, to where the 10,000 in-lb assemblies have a bell 6 in. dia.

Another existing application of this new device is on a portable pipe threader. Another is used in the power transmission system of a machine having a series of rolls. Blood Brothers Machine Division, Rockwell Spring & Axle Company, Allegan, Mich.

For more information—
Circle 1, inside back cover

Slope Reader for Data Reduction

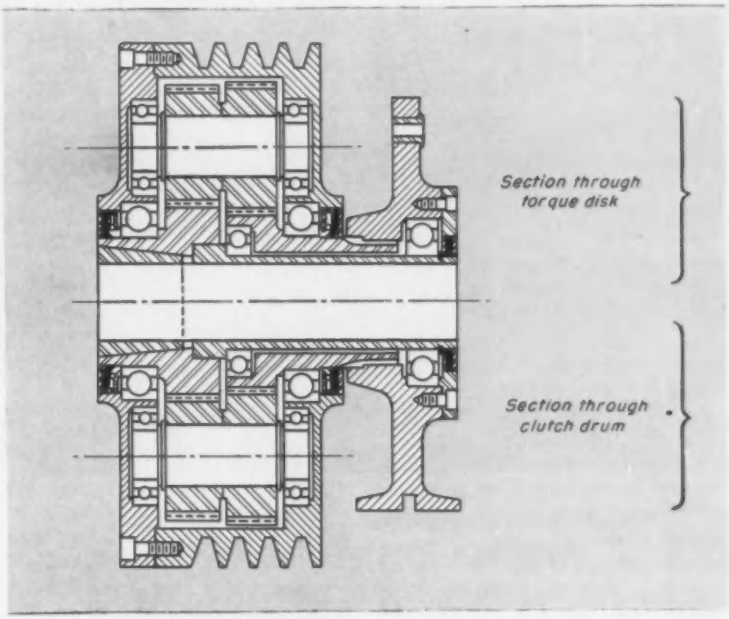
This instrument is designed to obtain the derivative or slope of a plotted curve. It yields the normal as well as the slope directly, without computation. It is not necessary to know the exact equation of the graphical curve to determine derivatives. However, if an equation should be available, a simple plotting of the area of interest on coordinate axes allows the use of the new device to determine the slopes.

The accuracy of this instrument is said to be greater than that obtained with drafting instruments used in graphical approximations, and is comparable to the practical accuracy required when taking derivatives calculated from known equations. In addition to the obvious uses for the instrument in obtaining slopes and derivatives, it has application in such specific problems as the layout of cams in machine design, layouts involving tangents and intersections to the curve lines in aircraft design and road planning, and the compiling of velocity and acceleration data from displacement curves.

A flexible flat spring is mounted on a pivot at the new device's center, the pin parallel to the flat side of the spring. A light metal indicator is mounted perpendicular to the spring at the center, also being perpendicular to the pivot pin. Since the other end of this indicator registers on a circular scale, any deflection of the spring rotation about the pivot pin is immediately transmitted to the scale. The scale is divided into four quadrants to read the sign as well as the numerical value of the derivative. The deflection of the spring is controlled by the sliding of two widely spaced rods contacting the back of the spring. Two probes, located near the pivot also contact the back of the spring, giving fine adjustment control to the shape of the flexed spring. In operation it is necessary only to place the pivot at the point of interest on a given curve, adjust the spring to coincide with the shape of the curve, and read from the scale.

In using the reader, the square frame containing the movable indicator mechanism is oriented with the grid lines of the curve being measured. The pivot pin is located on the point of the curve where the derivative is to be taken. After the preliminary adjustment of the unflexed spring to a position approximately tangent to the curve, the spring is adjusted to conform to the shape of the curve. The derivative or slope is read from the circular scale. By orienting the frame at 90 deg counter-clockwise to the derivative position, the normal to the curve can be read. Gerber Scientific Instrument Co., 162 State St., Hartford, Conn.

For more information—
Circle 2, inside back cover



Pulley With Built-in Gear Reduction

Looking like an ordinary V-belt pulley, this device is equipped with built-in gear reductions ranging from 7:1 to 700:1 standard, and up to 8000:1 on special order. It produces, in the pulley itself, two reductions: first, from motor pulley to the reduction pulley through the V-belt drive, and, second, through internal planetary gearing in the pulley interior.

Unit consists of a housing with V-belt grooves, a cover, a held gear, an output gear and two or four pinions, together with necessary bearings. The mechanism runs in a bath of oil. It can also be adapted to gear or chain drive and can be supplied with a friction clutch added. Hart Reduction Pulley Co., 426 W. Main St., Waukesha, Wis.

For more information—
Circle 3, inside back cover

CONTINUED ON PAGE 226

Solenoid Valve with Floating Diaphragm

In these units, the synthetic diaphragm "floats" free, providing greater fluid flow at lower pressure differentials. Pilot-operated with no metal-to-metal contacts to wear, they are guaranteed by the manufacturer for a period of 18 months.

Usable for the control of water, air, brine, light oils, industrial gas, Freon 12 and 22 and other non-corrosive fluids at temperatures from 0 to 225 F, these valves have been employed in air conditioning, refrigeration, hot water heating, laundry equipment, dishwashers, hydraulic pressure systems, automatic control installations. They operate with any pressure differential between 1 and 250 psi.

Available in a wide variety of sizes, with port openings from $\frac{3}{8}$ to $1\frac{1}{4}$ in. dia. There is a choice of screw, solder or flare connections. Coil assemblies for all valves are the same size and are readily interchangeable with the simple insertion of the coil with the desired electrical characteristics. Jackes-Evans Mfg. Co., 4427 Geraldine Ave., St. Louis 15, Mo.

For more information—
Circle 4, inside back cover

Plastic Resin for Molding, Blending, Laminating

This resin is a solid prepolymer of diallyl phthalate. It can be used as a cross-linking agent for low-shrink polyesters, in the formulation of molding powders, in solutions for application to standard textiles—glass cloth, glass roving, or paper, for fabrication into finished products, and as a component in combination with other resins for numerous applications.

"Dapon" is a free-flowing, white powder which is thermoplastic and soluble in low molecular weight ketones, benzene. It is insoluble in alcohols, water and petroleum solvents. If a peroxide catalyst is incorporated by suitable means into the resin or its solution, either with or without the addition of monomer, this resin, upon heating and the application of mild pressure, thermosets to a finished product which no longer is soluble or thermoplastic. This finished product is similar in physical properties to that obtained through the curing of other similar prepolymer resins currently available in solution.

In the manufacture of Dapon, diallyl phthalate has been polymerized to a point where practically all of the change in specific gravity has taken place, thereby assuring that little shrinkage will take place in final cure. Ohio-Apex Div., Food Machinery & Chemical Corp., Nitro, W. Va.

For more information—
Circle 5, inside back cover

Potentiometer Measures 0.430 x 0.250 In. Dia

The basic unit may be flush-mounted to the chassis, mounted in conventional diode clamps, or mounted by its $1\frac{1}{2}$-in. tinned leads. The basic type 101-A can also be provided with a flanged and threaded nickel-plated brass body. The threaded bushing configuration is specified as Type 101-B.

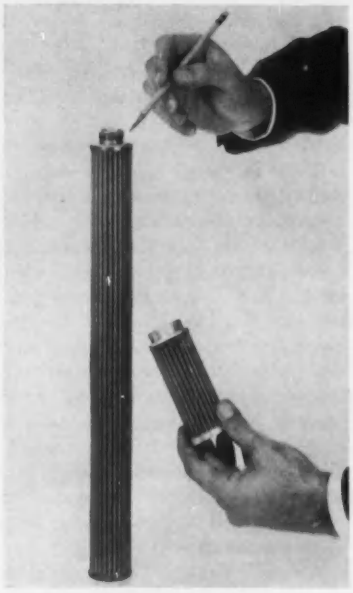
Electrically this potentiometer can be supplied in standard resistances of 680, 1000, 1500, 2200, 3300, 4700, and 6800 ohm. Power dissipation is $\frac{1}{4}$ w at 20 C. A minimum of 100 turns of resistance wire is used for all values of resistance. Noise resistance is less than 100 ohm. Winding angle is 320 deg nominal, and breakdown voltage is 1000 v. Carter Mfg. Corp., 23 Washington St., Hudson, Mass.

For more information—
Circle 6, inside back cover

Epoxy Resin-Glass Fiber Tubing

This reinforced tubing is available in lengths up to 9 ft. Diameters go down to $\frac{1}{16}$ in. ID, and wall thickness to $\frac{1}{8}$ in. Resistance to temperature as high as 350 F is claimed. Moisture absorption is less than 1 per cent, after 90 days immersion. Lamtex Industries, Inc., 51 State St., Westbury, N. Y.

For more information—
Circle 7, inside back cover



Filter Handles Fluids Up to 1000 F

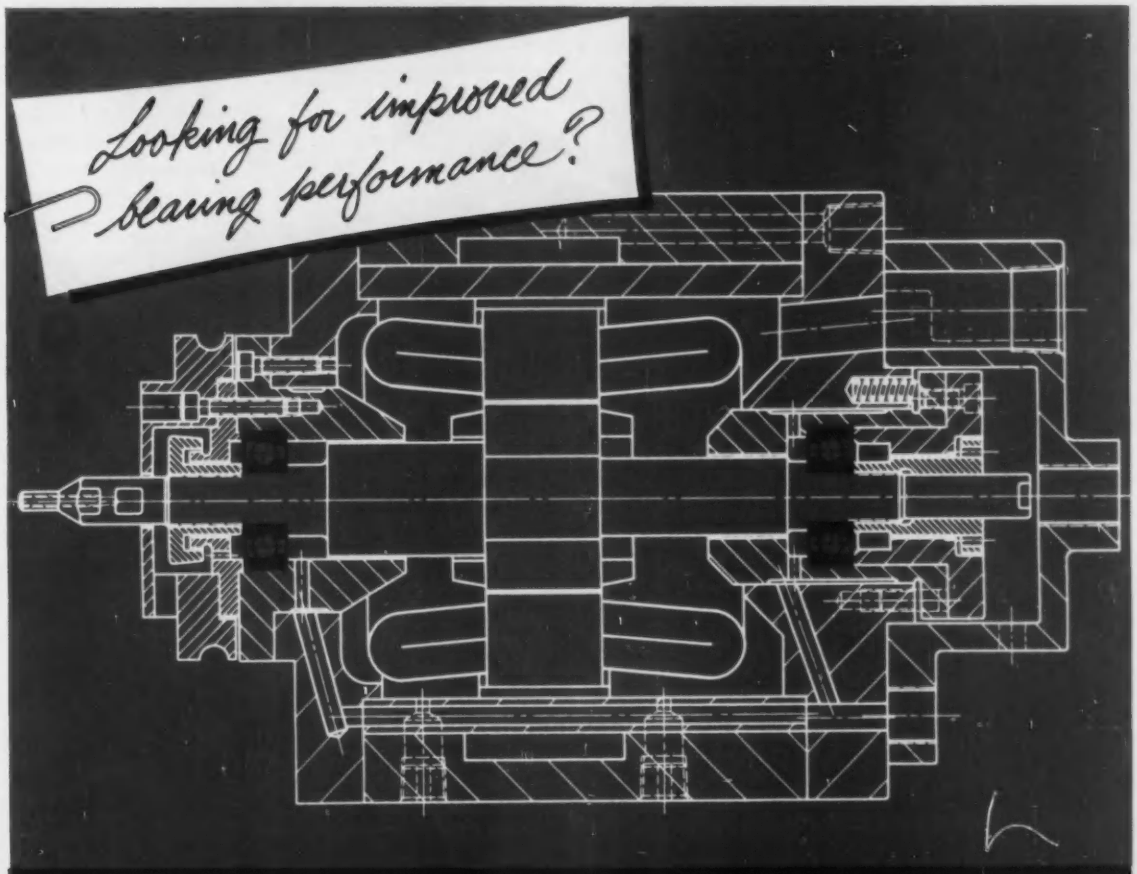
Made of sintered metal, this filter is reported to remove particles as small as 1 micron in size from a range of fluids, including nitric acid, hydrochloric acid, sulphuric acid, phosphoric acid and strong alkalies.

The one-piece sintered element can be made in a variety of diameters and lengths and its radial fin construction can be supplied in specified depths and numbers of convolutions to give extended area within a confined space. Varying flow rates are also available. Filters of stainless steel, Monel and other metals can be made as required.

Permeability and uniform porosity

CONTINUED ON PAGE 228

Looking for improved bearing performance?



over 14 billion revolutions...

– and still going strong

Fafnir Super-Precision MM201W1-CR spring-loaded ball bearing, the type specified for wheelhead illustrated.

Fafnir-equipped, high-speed, oscillating grinder wheelhead demonstrates machine tool progress in performance

This extraordinary record has been made on the production line by a Pope-built wheelhead, grinding the races of extra-precision ball bearings. The hi-frequency motorized wheelhead operates at 72,000 rpm. The motor is water-cooled and bearings lubricated by means of an oil-air mist system.

When designing this oscillating grinder wheelhead, Fafnir engineers worked together with the Pope Machinery Company engineers in the selection and application of bearings. The type of bearing recommended is shown at the left and its application in the drawing above. Its performance record, according to Pope, demonstrates progress to match today's improved machine tools.

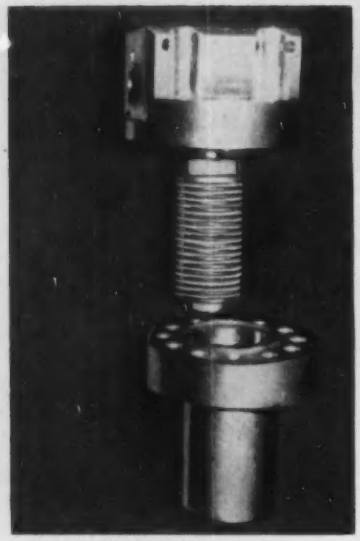
Whatever your bearing problem, a few minutes spent with a Fafnir representative may be the means of solving it as successfully. Write The Fafnir Bearing Company, New Britain, Connecticut.

FAFNIR
BALL BEARINGS

MOST COMPLETE LINE IN AMERICA

can be varied as to pore size desired. The new filter can handle differential pressures to 500 psi. Dept. S, Purolator Products, Inc., Rahway, N. J.

For more information—
Circle 8, inside back cover



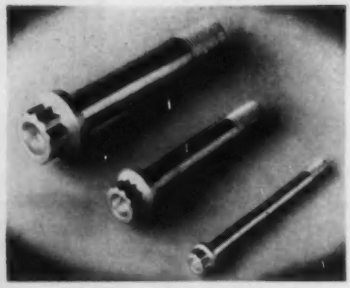
Porous Stainless Steel Filters

This filter is said to make it possible to filter under unusually severe conditions—temperatures up to 1200 F, defferential pressures of 2000 psi, and corrosive liquids or gases. The elements are produced from mixtures of spherical and non-spherical powdered stainless steel alloys. These filters are built to standard AN dimensional specifications. Cuno Engineering Corp., 100 S. Vine St., Meriden, Conn.

For more information—
Circle 9, inside back cover

Bolts of 180,000-200,000 Psi Tensile

These high tensile strength, aircraft-type fasteners are said to have exceptional resistance to dynamic fatigue or shock loading. Controlled forging of the twelve-point head configuration provides optimum grain-flow lines necessary for long fatigue life. Cold-working of the fillet between bolt head and shank further strengthens this fatigue-prone area. These external-wrenching bolts are being produced in standard diameters ranging from ¼ to 1½ in. Bolts are made from 4340 and 8740 alloy steels and are cadmium plated by the fluoborate method. Standard Pressed Steel Co., Jenkintown, Pa.

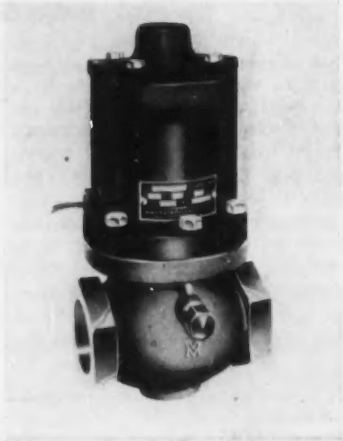


For more information—
Circle 10, inside back cover

Packless Solenoid Valve

Typical applications of this valve are in lifting platforms, hoists, presses, freight and passenger elevators, dumbwaiters. Designed for use with soluble oil, hydraulic oil or water, at fluid temperatures up to 212 F, these valves are of the piloted piston type. The bodies are cast from high pressure valve bronze in a globe pattern, with threaded ends. The pilot valve is stainless steel. The main valve is a composition disc in a readily replaceable standard Jenkins size.

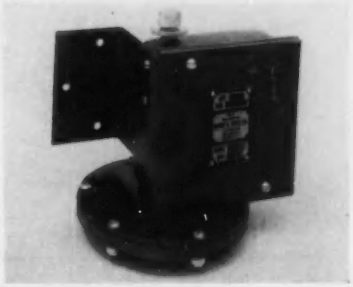
Both normally open and normally closed models have a uniform working range of 300 psi, max. Magnatrol Valve Corp., Hawthorne, N. J.



For more information—
Circle 11, inside back cover

Regulated High Voltage Power Supply

This electronically regulated supply is designed for use with photomultiplier tubes, counters and other devices requiring a closely regulated, well stabilized voltage. The use of a zero-drain, thermally insulated battery voltage reference is said to allow long term stability and unusually good absolute accuracy in setting output voltage. Both positive and negative are insulated from the chassis, and either can be grounded.



The output voltage changes less than 0.01 per cent from zero to a 1 ma load. A 10 per cent change in input voltage causes less than 0.05 per cent change in output. Ripple is less than 0.003 per cent of output voltage. The front panel is designed for standard relay rack mounting, 19 x 7 in. Scientific Specialties Corp., Div. Norden-Ketay Corp., Snow & Union St., Boston 35, Mass.

For more information—
Circle 12, inside back cover

Vacuum Static Pressure Switch

This control is expected to find wide application as an air vacuum interlock switch for use in equipment requiring safeguards to assure a specific vacuum to prevent a hazardous condition. It is applicable for use in

CONTINUED ON PAGE 230

FLEXIBLE SHAFT IDEAS for ENGINEERS

One part does the work of many when you use a flexible shaft

Design simplification is one of the reasons why it pays to use S.S.White "Metal Muscles"®

Difficult alignment problems easily solved with flexible shafts

THE ADAPTABILITY of a flexible shaft to almost any operating position makes it an extremely useful means of correcting misalignment difficulties.

In the application shown, for instance, a power drive flexible shaft is incorporated into the drive of a gear pump. Its use here permits adjustment of the pump shaft drive pulley when it becomes necessary to regulate the tension of the V-belt driving the pulley.

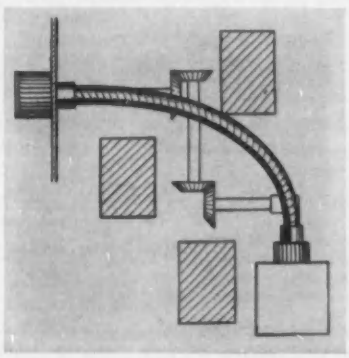
How to pick the right flexible shaft

ONE SURE WAY *of getting the right flexible shaft for your needs is to rely on the advice of S.S.White engineers. Their long experience with the problems involved will assure you of sound answers. They know which type shafting will work best under your given set of conditions. It costs nothing to take advantage of this service. It will save you plenty of time and money.*

IT'S A DESIGNER'S AXIOM that simplification is one of the most effective ways of reducing product costs. By so doing, you save weight, you eliminate a number of unnecessary parts and you reduce assembly time and costs.

Eliminating Parts

When it's a question of transmitting rotary power or providing remote control, especially where turns or alignment are involved, an S.S. White flexible shaft is an efficient cost-saving solution. The illustration below demonstrates why this is so.



One flexible shaft is all it takes to do a job that might otherwise require an entire system of bevel gears, straight shafts, universals, etc. Added to this is the fact that installation is greatly simplified and alignment problems are eliminated.

90% Cost Reduction

Actual cost figures on a control set-up for a large dual hydraulic power system dramatize how effectively flexible shaft simplification can cut costs.

In this case, 35 parts including universal rods and bevel geared elbows were being used to transmit control from two handwheels to a motor control unit and thence to two hydraulic motors.

Without any necessity of redesigning the equipment, 4 standard S.S.White flexible shafts were used in place of the original control system. The result was a 90% savings – and, incidentally, 100% improved performance.

What About Your Application?

Perhaps your own designs cannot realize benefits as outstanding as this. But the chances are good indeed, that, if you are not now using them, you'll be able to handle many remote control and power drive applications better and at less cost with an S.S.White flexible shaft.

USEFUL FLEXIBLE SHAFT DATA

Bulletin 5601 has concise information on how to select and apply flexible shafts. Send for a copy.

F5-2

S.S.White

FIRST NAME IN FLEXIBLE SHAFTS

S. S. WHITE INDUSTRIAL DIVISION, DEPT. D, 10 EAST 40th ST., NEW YORK 16, N.Y.

Western Office: 1839 West Pico Blvd., Los Angeles 6, Calif.

combustion equipment, air conditioning, industrial applications.

The control employs a dusttight enclosure having a rubber seal. Range is adjusted by means of a knurled knob located outside the housing. Standard units are available for 0-1 and 0-4 in. water column vacuum. Minimum on-off differentials of 0.1 in. water column are available. The electrical ratings of the single-pole, double-throw switch are 15 amp at 120-250 v, ac, ½ hp, or 125 va, pilot duty. Henry G. Dietz Co., 12-16 Astoria Blvd., Long Island City 2, N. Y.

For more information—
Circle 13, inside back cover

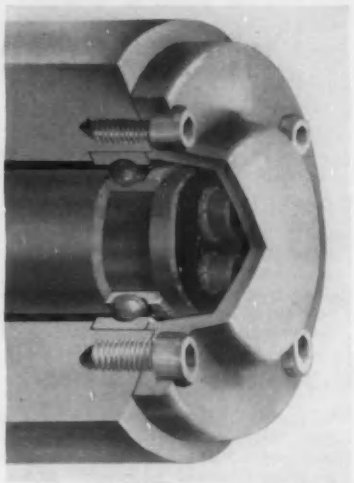
Plane Swivel Joints

Designed for hydraulic or pneumatic service on pipe, tubing or hose, these joints are of the single-plane swivel type. They are designed, primarily, to provide for up to 360 deg turning or rotating motion on machinery or other places where flexible piping or tubing is required.

These new joints are being made in ball bearings and thrust bearing types suitable for pressure as high as 2000 psi, depending on size of joint. Temperature ratings range from −20 F to 225 F. The joints are equipped with O-ring seals and have low rotating torque at all pressures. The bearings are sealed and require no lubrication maintenance in normal service.

Standard sizes are ¼ and ½ in. Also, ⅜ and ¾ in. are available on quantity orders. The joint casing is machined from aluminum and the rotating shaft from steel. Overall length of the ¼ in. size is 2¾ in. Barco Mfg. Co., Dept. J-22, 500 N. Hough St., Barrington, Ill.

For more information—
Circle 14, inside back cover



Bearing Housing Caps

A line of bearing housing caps are made of cast iron and finish-machined, ready for assembly. These units are available in 400 different styles and sizes to meet most application requirements of regular, snap ring, sealed and shielded ball bearings as well as roller bearings. Design Aids, Inc., 130 N. 7 St., Newark 7, N. J.

For more information—
Circle 15, inside back cover

Transducer of Magnetic Reluctance Type

A pressure transducer is being offered in full scale ranges from ¼ to 100 psi. In differential pressure service the nominal maximum line pressure rating is 500 psi. The transducer has an accuracy rating of ±1 per cent full scale, and may be operated in recording and control systems compatible with inductance ratio input devices.

The pressure sensing element is a

diaphragm, magnetically coupled to a pick-off system embedded in the body, resulting in extreme mechanical rigidity and ability to measure the high frequency components of pressure transients. The Model P-1 weighs 13 oz, and is 1¾ x 2½ in. long. Pace Engineering Co., 6914 Beck Ave., N. Hollywood, Calif.

For more information—
Circle 16, inside back cover

Glass Pipe Armored With Glass Fiber

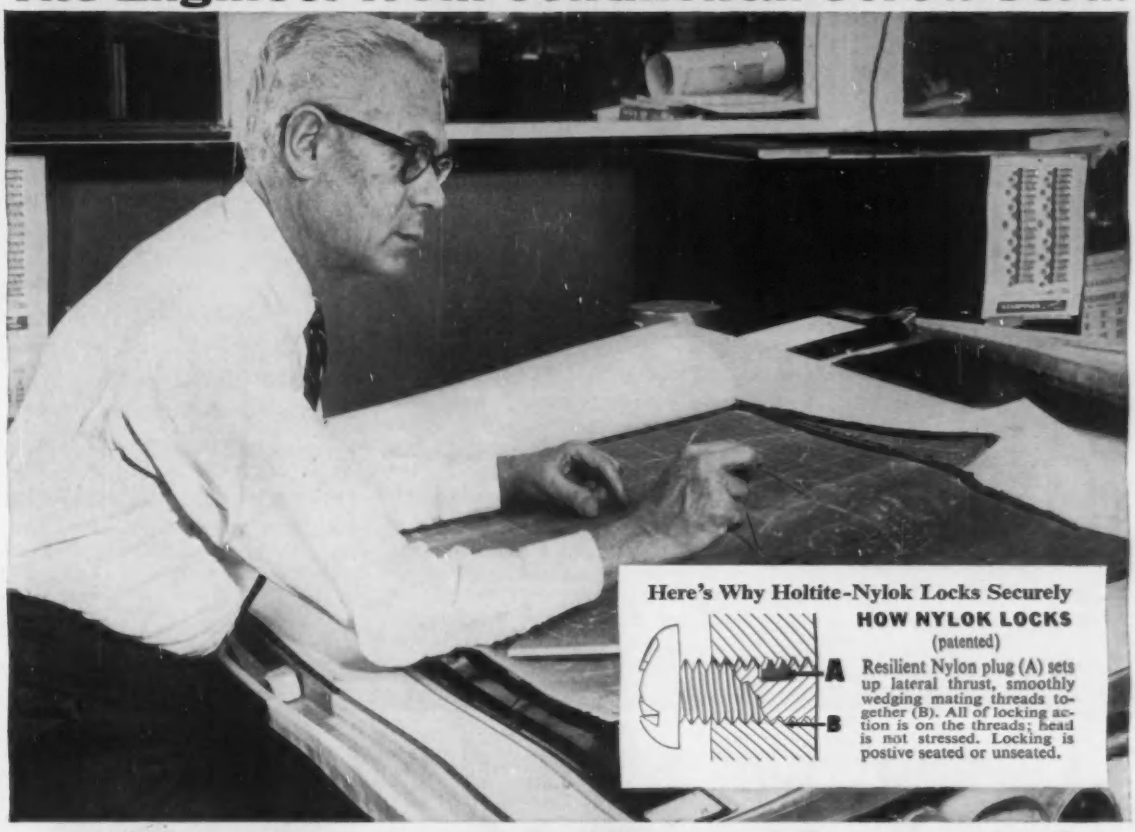
A seamless sleeve of glass fiber, fitted snugly over glass pipe and impregnated with polyester, forms an armor designed to protect the pipe against rough handling and to carry the same work load as the pipe in case of glass failure. The jacket is nonflammable and is cut to fit the length of the pipe. It is corrosion resistant, unaffected by weather, moisture or rodents, and has a maximum operating temperature of 30° F.

The polyester resin, with which the glass fiber is impregnated, jells and hardens the sleeve to form a tight-fitting second pipe as strong as the glass pipe it surrounds. The resin itself is resistant to hot, cold and salt water and to most acids.

The new armor for glass pipe is only $\frac{1}{16}$ in. thick and allows sufficient visibility to determine liquid levels in the pipe. The mechanical strength of the glass piping remains the same

CONTINUED ON PAGE 232

The Engineer from Continental Screw Co. ...


Here's Why Holtite-Nylok Locks Securely
HOW NYLOK LOCKS
(patented)
A
B
Resilient Nylon plug (A) sets up lateral thrust, smoothly wedging mating threads together (B). All of locking action is on the threads; head is not stressed. Locking is postive seated or unseated.

...will study your specific requirements for Holtite Nylok Screws at no cost to you!

Talk to the Engineer from Continental about 1-piece self-locking screws and bolts

Manufacturers all over the nation are saving time and money by switching to Holtite Nylok Screws. These amazing self-locking screws and bolts eliminate safety wire, lock washers, jam nuts, and various other locking devices.

The secret behind their smooth efficiency is a nylon insert in the threaded section which provides a positive-locking action. Seated or unseated, they lock where they stop. Our engineers will be happy to study your specific requirements and make the correct recommendations *at no cost to your company.*

Remember, Holtite Nylok Screws and Bolts give you these advantages:

1. Positive locking
2. One piece; eliminates separate auxiliary parts
3. Readily replaced
4. Interchangeable
5. Re-usable
6. Locks seated or unseated
7. Defies vibration
8. No harm to mating threads of parts
9. Acts as a seal for gases and liquids under high pressures
10. Locks where it stops

It will pay you to talk over your fastener problems with the Continental Engineers.

Only Continental Engineers Are Required To Have This Training

Each engineer at Continental is required to undergo thorough experience producing ground thread taps and gages, with their exacting screw thread dimensions. This special training is passed on to you—at no extra cost.

CONTINENTAL SCREW COMPANY INC. ★ 1904

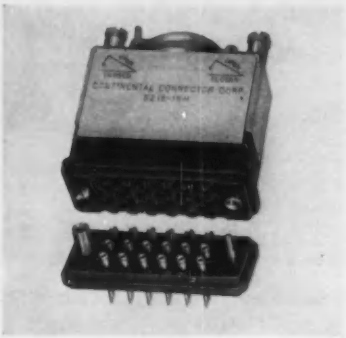
You Can Always Count on Continental

Continental Screw Co.

Manufacturers of Holtite Fastenings
New Bedford, Massachusetts, U.S.A.

even with the armor, the manufacturer states. This armored pipe will be available in stock sizes of 1 to 6 in. ID, lengths 1 to 10 ft. Elbows, crosses, ties, reducers, returns bends, 45 deg bends are being made. Corning Glass Works, Corning, N. Y.

For more information—
Circle 17, inside back cover



Connectors With Polarizing Screwlock

Series E-Z 16 is available in 12, 18, 24 and 34 contacts with solder cup for No. 16 AWG wire or solderless wiring taper pin. Individually spring-loaded pin contacts assure quick release with low insertion force and practically no disengagement force. Aluminum hoods with cable clamp and cable mounting bracket for top or side cable opening can also be supplied on order.

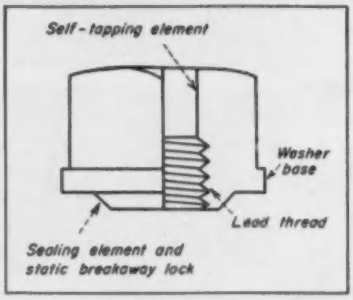
A choice of molding compounds includes mineral filled melamine, plaskon reinforced (glass), Alkyd 440A or Orlon-filled diallyl phthalate. DeJUR-AMSCO Corp., 45-01 Northern Blvd., Long Island City 1, N. Y.

For more information—
Circle 18, inside back cover

Nylon Stop Nut

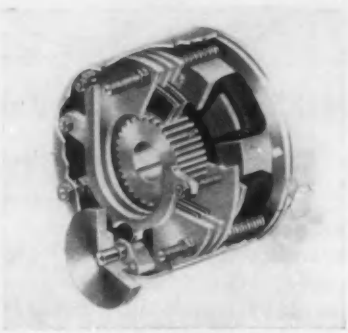
This one-piece, washer-faced, resilient hexagon nut is said to be simultaneously self-tapping, locking and insulating. According to the manufacturer, it is molded to American standard flats widths dimensions for use with standard installation and removal tools.

Completely re-usable, material is



displaced as the screw turns the nut into resilient material. A counter-compressive force is exerted against the screw as continuing drive-torque is applied, resulting in a tight friction lock. A new design principle reportedly aligns the screw in the hole, holding it tightly against wobble, chatter, noise and vibration. The nut is currently available in sizes No. 4, 6, 8, 10, and ¼ in. American Screw Co., Willimantic, Conn.

For more information—
Circle 19, inside back cover



Electric Brake With Reduced Power Loss

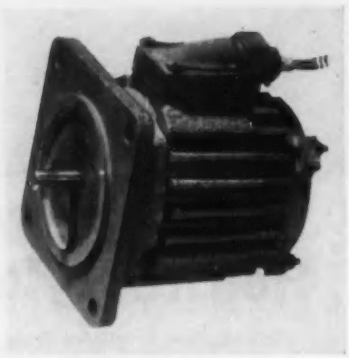
This brake has a magnet with a circumferentially wound core and armature, which the manufacturer claims reduces power losses by 80 per cent. Preformed coils inserted in slots milled in the core are the equivalent of six E-magnets, and because this number is divisible by two or three, the brake may be connected to either two or three-phase motors with equal facility.

Another advantage claimed for the magnet is high pull-in force at large air gaps. This is important in electric brakes because brake lining wear causes the armature to recede from the pole faces, and in the case of a lining that has been almost worn away may displace the armature so far that the magnet cannot attract it against the force of the brake springs. Star-Kimble Motor Div., Miehle Press & Mfg. Co., Bloomfield, N. J.

For more information—
Circle 20, inside back cover

Positive Start, Lightweight Actuator Motor

An aircraft motor with a starting torque of 22 in-lb weighs 5 lb, and is totally-enclosed and explosionproof for duty under severe environmental conditions. This motor operates on three-phase, 400 cps, 200 v, ac, up to altitudes of 50,000 ft. It delivers 2.2



hp intermittently at 8400 rpm. Duty cycle is on for 15 sec, off for 3 min, on for 15 sec, off for 15 min, repeated continuously. U. S. Electrical Motors Inc., Box 2058, Terminal Annex, Los Angeles 54, Calif.

For more information—
Circle 21, inside back cover

Ultra-Thin Glass Paper

An engineering material that is essentially microglass fibers to which a binder and/or impregnant can be added to achieve desired electrical, chemical and thermal properties. The tissue-like film is available in thicknesses ranging from 0.005 to 0.03 in. and widths up to 40 in. Impregnations used successfully to date include

CONTINUED ON PAGE 234

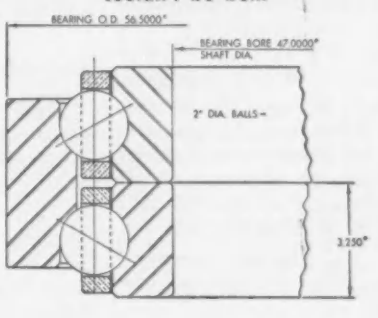
Here are the bearings that "couldn't be built"... *as produced by Kaydon*

THE manufacturer who wanted these bearings had been told they "couldn't be built." Or at least that's what he'd been told *until* he contacted **KAYDON**. What he required was a bearing 56½" in diameter combining high capacity, and exceptional precision for concentricity and face runout that would fit in limited space.

KAYDON designed a double-row angular contact ball bearing (see sketch at right). Actual tests have proved that the bearing fulfills every requirement.

If your designs require bearings of exceptional capacity, close-tolerance precision and/or very thin section — it will pay you to contact **KAYDON** of Muskegon. **KAYDON** has a long-standing reputation for accomplishing the near impossible.

CROSS SECTION — *The bearing that couldn't be built*



Just Out! Get your copy of the new **KAYDON** *Reali-Slim thin bearing catalog No. 54.*

THE KAYDON ENGINEERING CORP.

MUSKEGON • MICHIGAN

KAYDON Types of Standard and Special Bearings:
Spherical Roller • Taper Roller • Ball Radial • Ball Thrust • Roller Radial • Roller Thrust • Bi-Angular Bearings

K543

PRECISION BALL AND ROLLER BEARINGS

melamine, epoxy, silicone, polyvinylchloride, polytetrafluoroethylene and polyester preparations.

Wet strength is approximately 70 per cent of dry tensile, which ranges from 95 to 880 psi; breaking strength varies from 200 to 1,350 g per in. of width. American Machine & Foundry Co., 261 Madison Ave., New York 16, N. Y.

For more information—
Circle 22, inside back cover

Miniaturized Multi-Turn Potentiometer

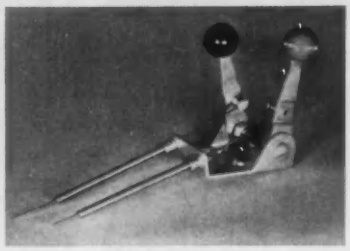
Available with either flexible or turret-type terminals, these potentiometers have a 1 in.-oz maximum starting torque. Weight is 1.2 oz. Case dimensions: 1 x 1 in. long from mounting surface to rear of case.

Rated at 2 w at 40 C, standard linearity is ±0.5 per cent. Resistance values from 500 to 100,000 ohm. Standard tolerance is ±5 per cent; however, tolerances as low as ±0.5 per cent can be obtained. Circuit Instruments Inc., P. O. Box 355, 1927 First Ave. S., St. Petersburg, Fla.

For more information—
Circle 23, inside back cover

Twin Lever Remote Control

This twin lever control is for the remote operation of clutch and throttle on small internal combustion engines, such as for lawn mowers, outboard motors, midget cars, motor bikes and similar applications. Lever length is 3⅛ in. with black red plastic



knobs to identify function. Maximum travel of control is 1⅞ in. Arens Controls, Inc., 2017 Greenleaf St., Evanston, Ill.

For more information—
Circle 24, inside back cover

Self-Locking Set Screws

A headless, self-locking set screw particularly suited for soft metal applications spreads slightly after insertion, causing a locking action. However, when desired, the screw may be removed and re-used, without any appreciable loss in locking efficiency.

A screwdriver with parallel shanks is used so that engagement is at the bottom of the slot. By moving the driver from side to side the locking effect may be increased as desired. Set Screw & Mfg. Co., 153 Main St., Bartlett, Ill.

For more information—
Circle 25, inside back cover

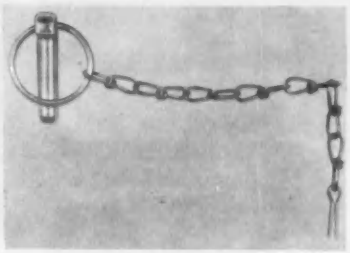
Fhp Motor Generator Sets

These motor-generator sets, in frame sizes 44, 66 and 74, are used as a power supply for product testing in plant laboratories, as power supply for variable speed motors, and as self-contained exciters of larger units. They are also said to be used extensively to supply energy for such industrial devices as magnetic chucks.

Continuous operation at rated load is made possible by a ventilating system incorporating a fan on the shaft between the units. Air enters through side vents, passes over both units, and is exhausted through the bottom of the set. Both rotors are mounted on a common shaft.

These compound-wound units are of drip-proof, ball-bearing, solid-base design. They are available in various input combinations of standard frequencies, voltages, and phases, and with 250, 500 and 750 w, d-c outputs. General Electric Co., Schenectady, N. Y.

For more information—
Circle 26, inside back cover



Snap Ring Holds Lock Pin In Place

This pin is held in place by a tempered steel snap ring which clicks over the end of any shaft in which the pin is inserted. These snap rings are wound so that the direction of spiral keeps them folded down against the pin. In addition, holes for the ends of the rings are drilled only partially through the pin, allowing the ends of the ring to bottom in the hole. These pins are being manufactured in 7/16 and ¼ in. sizes, with two snap ring sizes and optional retaining chains. Danuser Machine Co., Fulton, Mo.

For more information—
Circle 27, inside back cover

Miniature Connectors

To lock these connectors, mating parts are pushed together until a snap is felt. To disconnect plug, a quarter turn of mating parts and a slight pull separates unit. Positive connection of center conductor to

CONTINUED ON PAGE 236

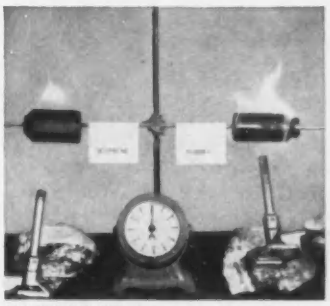
Using

DU PONT ELASTOMERS

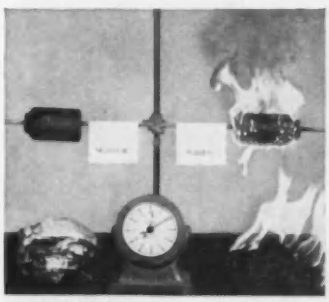
NEOPRENE-HYPALON®

in Design

NEOPRENE ROLLERS PASS FLAME TEST!



PRINTING ROLLERS of neoprene (left) and natural rubber (right) are exposed to the flame of Bunsen burners until they ignite.



IN FIVE SECONDS after burners are removed, flame on neoprene roller is out. After 69 seconds, drippings from flaming rubber roller have ignited newspaper.

This test convinced management of the New York *Daily News* that neoprene printing rollers offer an extra measure of safety over natural rubber. Today, they flame test all rollers before they buy—and neoprene rollers are the only rollers that meet the test.

Neoprene's resistance to flame may well be useful to you as an added safety factor in your product designs. And neoprene offers resistance to abrasion, oil, heat, and chemicals as well. For all general-purpose applications, you can count on neoprene for long-term service. Clip coupon for further information.

Resilient gaskets of HYPALON® unaffected by 2% ozone

Re-usable after 2 years in ozone generators

For two years now Emery Industries has been using HYPALON synthetic rubber gaskets to seal its ozone generators. The company's ozone-producing installation is the largest in the country. Its operations supervisor, Robert Peters, made this report on HYPALON. "No failures with HYPALON gaskets in two years, even though they've been exposed to 2% ozone."

Design of the generator

The generator used by Emery Industries consists of a steel shell packed with a series of glass tubes individually encased in an electrically charged metal enclosure. A conductor carries an opposing charge through the glass tubes to make, in effect, a large electrical condenser. Dry oxygen is passed along the length of the glass tubes and converted to ozone. The generators are closed at each end by a dished head sealed with HYPALON gaskets.

HYPALON replaces plastic

Formerly, plastic gaskets were used in the generator. While unaffected by ozone, plastic gaskets had to be replaced after each maintenance checkup because they were too rigid for re-use. HYPALON gaskets, even after two years of service, retain their resilience and are still re-usable. Says the generator manufacturer, Welsbach Corporation, in Philadelphia: "We use HYPALON gaskets because they have the best over-all combination of properties of any we've found—including ozone inertness, resilience and cost."

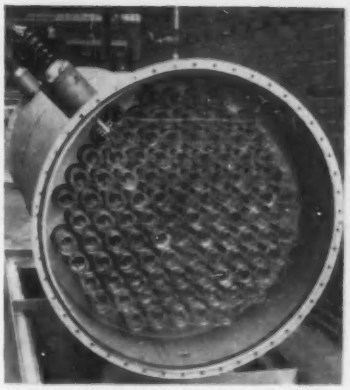


Photo courtesy Welsbach Corp., Phila., Penna.

HYPALON gasket on ozone generator showed no sign of deterioration after two years of service.

Designing with HYPALON

HYPALON means extra-long life at lower operating costs for resilient products subject to severe service conditions. It can operate at temperatures from 250°F. to 350°F. It is particularly resistant to most oxidizing chemicals. And HYPALON resists weather and sunlight attack and can be compounded in an unlimited range of stable colors. For more information about HYPALON, clip and mail the coupon below.

DU PONT

REG. U.S. PAT. OFF.

HYPALON *is a registered trademark of E.I. du Pont de Nemours & Co. (Inc.)*

BETTER THINGS FOR BETTER LIVING . . . THROUGH CHEMISTRY

Please send further information and add my name to the mailing list for your free publications, the "Neoprene Notebook" and "Facts about HYPALON®," which show how the Du Pont elastomers are used in designing new products, improving old.

E. I. du Pont de Nemours & Co. (Inc.)
Elastomers Division, Dept. PE-2
Wilmington 98, Delaware

Name_____ **Position**_____

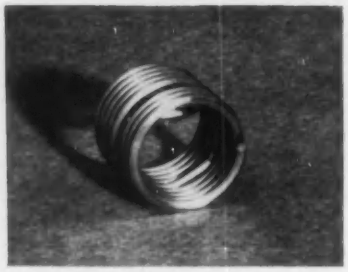
Firm_____

Address_____

City_____ **State**_____

connector guards against loss of contact, from either severe vibration or from someone accidently pulling on cable. Connectors can be easily assembled in field and no special tools are required for the job. Nugent Electronics Co. Inc., 621 E. 8 St., New Albany, Ind.

For more information—
Circle 28, inside back cover



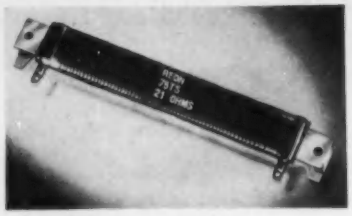
Eliminates Washers, Lock-Nuts, Wires

This insert is a companion product to the manufacturer's original wire screw thread insert. Both are made of stainless steel. Both provide 60-deg threads. Both of these fastenings are installed with similar tools by the same methods.

The new insert exerts a strong locking effect on a screw fastener because one or two coils in the middle of the insert are generally octagonal instead of being perfectly round. As the screw passes through this area, the gripping coils are forced to assume a circular shape. The chords of the "circle" press on the screw, giving the locking effect, which is said not to be diminished through many cycles of disassembly.

The locking insert is immediately available in sizes 10-32; $\frac{1}{4}$-28; $\frac{5}{16}$-24; $\frac{3}{8}$-24. Heli-Coil Corp., Danbury, Conn.

For more information—
Circle 29, inside back cover



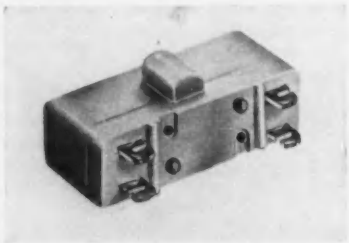
Subminiature and Miniature Resistors

Resistors are available in open bobbin style impregnated or hermetically sealed by epoxy encapsulation. Available wattages in these new components are from 0.1 to 2.5 w and ohmic values up to 2.5 megohm. Reon Resistor Corp., Yonkers, N. Y.

For more information—
Circle 30, inside back cover

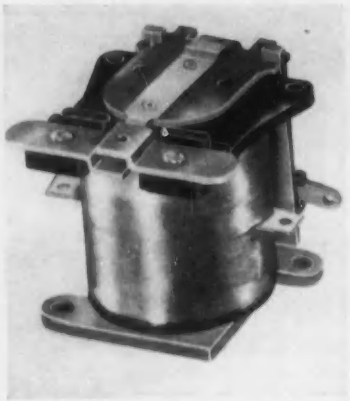
Small Switch Handles 40 Amp

The switch measures 1¾ x 3/64 x 43/64 in. It is designed for use in motor controls where size is a problem. Operating force is 30 oz and



electrical and mechanical life is 100,000 cycles. Current rating is 40 amp at 125/250 v, ac, 40 amp at 30 v, dc, and 30 v, dc, resistive. Electro-Snap Switch & Mfg. Co., 4218-30 W. Lake St., Chicago 24, Ill.

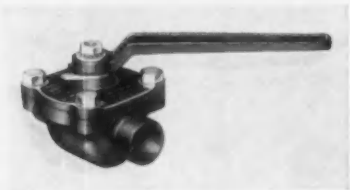
For more information—
Circle 31, inside back cover



Relay With 40 mw Sensitivity

This relay's coil resistance is rated as high as 22,000 ohm. It can take operating shock of 25 G, vibration over 10 G, 10 to 60 cps. Weight is only 1⅛ oz. Sterling Engineering, Princeton, Ind.

For more information—
Circle 32, inside back cover



Top Entry Ball Valve

Removal of the body cap permits reversing the cage assembly when direction of flow is changed. The direction of shut-off, changing of seat, and cleaning can be accomplished without removing the valve from the line. Valve is available in ½, ¾, 1 in. sizes. Rockwood Sprinkler Co., 38 Harlow St., Worcester 5, Mass.

For more information—
Circle 33, inside back cover

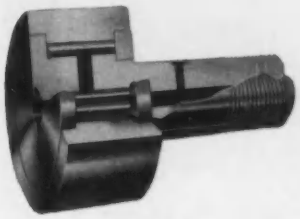
Starter Winding Relay and Overload Relay

The starter relay may be used in place of a centrifugal switch or magnetic relay, and will automatically connect and disconnect the starter wind-

CONTINUED ON PAGE 238

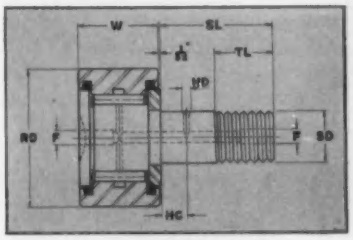
BEARING TIPS by McGill

BEARING BUILT FOR HEAVY-DUTY CAM LOADS



Camrol CF Bearings provide the ultimate in radial capacity, shock resistance and space economy for all cam actioned or guide and support roller applications. An extra heavy outer ring operates on a full complement of small diameter rollers supported by an integral inner race, roller retaining flange and stud. Designed as precision replacement for plain bearing or improvised bolt and bearing units.

New Sealed Bearing Adds to Versatility of Standard Cam Follower

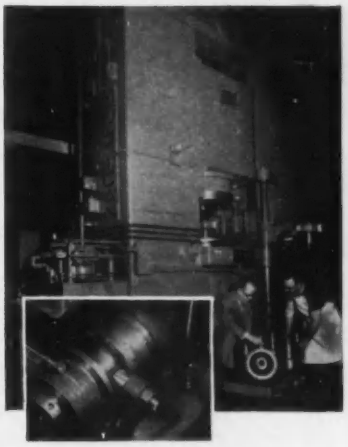


The new SCF series bearing keeps contamination out and lubrication in by means of specially-treated synthetic seals. The SCF bearing is interchangeable dimensionally with standard Camrol bearings.

140 Pages of Bearing Facts

Write for your copy of Catalog No. 52, a revised 140-page Bearing Selection Guide. It contains vital product information and 30 pages of engineering data.

CAMROL CF Bearings Cut Power Requirements on J. L. Ferguson Co. Packaging Machines



New Shear-Speed Shapers Achieve Greater Speed and Accuracy Using CAMROL CF Bearings

Michigan Tool Co. uses Camrol CF and CYR bearings in their new machines that produce gears up to 20 inches in diameter and up to 6-inch face widths in only 13 minutes. These bearings, acting as cam followers, accurately control cutting tool feed and relieve tools from the work on return strokes. They insure dependable, precision performance for automatic operation at high production speeds.

Up to 50 Camrol Bearings Used Per Machine

Used as load-carrying cam followers and as guide rollers in PACKOMATIC packaging machinery, McGill Camrol CF bearings have brought several desirable advantages to J. L. Ferguson Company in the eight years this firm has relied on Camrol Bearings.

Exceeding the performance of the roller and pin assembly formerly assembled in the Ferguson plant, the Camrol cam follower bearing has helped improve a variety of cam actuated operations on many of the versatile packaging machines built by Ferguson.

The Camrol CF bearings eliminate wear by reducing friction. This also reduces power requirements for the machines. The CF bearings cost less and are more easily applied than the previous assembly.

For trouble-free operation, up to 50 bearings per machine are now used by this company.

Insure performance with McGILL®

MULTIROL® GUIDEROL® CAMROL
Full Type Roller Bearings

McGILL MANUFACTURING COMPANY, INC., 201 N. LAFAYETTE ST., VALPARAISO, INDIANA

ing of any a-c motor, without flutters or hestitation, within seconds.

The overload relay is an automatic device, which provides protection against overloads, shorts and low current. Suitable not only for a-c motors or appliances, but also in charging equipment, instruments or any kind of electronic equipment.

Both items are thermally operated. Because of their construction they will function at very low current ratings. Maximum voltage rating, 250 v, ac. Current rating from 100 ma to 10 amp. Dimensions are 1⅞ x ⅞ x 1¼ in.; weight, 1¼ oz. E-T-A Products Co. of America, 5085 N. Elston Ave., Chicago 30, Ill.

For more information—
Circle 34, inside back cover

Circuit Breaker for Three-phase Motors

Designed to protect three-phase electric motors against overloads and overheating, this miniature circuit breaker and switch is available in built-in and surface types, with or without manual release. Overall dimensions are 2.342 x 1.614 x 1.673 in. width. Simple release mechanism provides rapid restoration of circuit after operation. Maximum voltage rating is 500 v, ac, and current ratings are from 100 ma to 25 amp. E-T-A Products Co. of America, 5085 N. Elston Ave., Chicago 30, Ill.

For more information—
Circle 35, inside back cover

Pressure Indicator

A pressure indicator recently introduced in this country from Switzerland has a quartz crystal transducer and a "composite" diaphragm. A soft corrugated Inconel ring seals off gases while the pressure itself is resisted by tiny wedge-shaped steel pieces that bridge the gap between the housing and inner element and support the soft diaphragm.

The gage is normally used to measure all pressures from less than 0.1 psi to greater than 3000 psi. With the high pressure adapter this range can be extended to above 20,000 psi. The same gage also measures vacuum.

The new indicator has been applied successfully on piston engine cylinders, intake and exhaust manifolds, fuel injection systems, rocket motors, jet engines, shock tubes, and hydraulic and pneumatic systems. Kistler Instrument Co., 15 Webster St., N. Tonawanda, N. Y.

For more information—
Circle 36, inside back cover

Miniature Circuit Breakers

This thermal single pole, overcurrent circuit breaker has been designed for a-c motors, instruments and other electrical and electronic equipment. Over-all dimensions: 2.44 x 1.221 x 0.571 in. depth; weight, approximately 1½ oz.

Maximum voltage ratings are 250 v, ac, and 24 v, dc. Current ratings: from 50 ma up to 25 amp. If the prospective short-circuit current does not exceed 6 amp, the breaker can be used for 230 v, d-c supply as well. E-T-A Products Co. of America, 5085 N. Elston Ave., Chicago 30, Ill.

For more information—
Circle 37, inside back cover

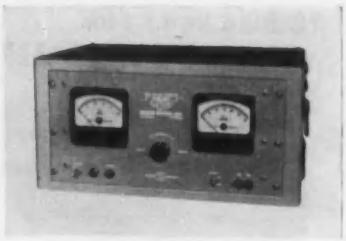
Large Size Stainless Plates From Stock

Fabricators of stainless steel plates who can use the widest and longest that are rolled can secure them from warehouse stocks, coast-to-coast. Plates up to 105 in. wide are being stocked in a number of thicknesses from ⅛ to 1 in. Stainless plates heavier than 1 in. are carried in widths of 80 in. Types available are 304, 304-L, 316 and 316-L. Joseph T. Ryerson & Son, Inc., Box 8000-A, Chicago 80, Ill.

For more information—
Circle 38, inside back cover

D-c Power Supplies

A line of dual magnetic, precision-regulated d-c power supplies in both 200 and 1000-w outputs employ magnetic amplifiers instead of tubes. All



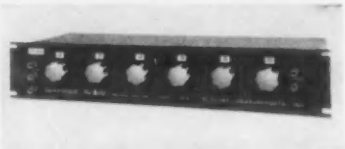
magnetic components are hermetically sealed.

Regulation precision of ±0.2 per cent over the entire d-c output range are obtained through the use of flux oscillators in connection with high-gain magnetic amplifiers. Power is smoothed by a filter consisting of iron-core chokes and a capacitor bank. Magnetic Research Corporation, 200-202 Center Street, El Segundo, California.

For more information—
Circle 39, inside back cover

Voltage Dividers For Rack Mounting

These dividers are fully shielded and usable from d-c through 10 kc. They can be mounted in any standard relay rack with 19 in. panel spacing.



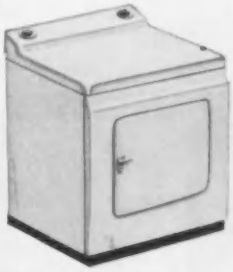
Both models have an input resistance of 10,000 ohm and a linearity of better than 25 parts per million. Electro-Measurements, Inc., 4312 S. E. Stark St., Portland 15, Ore.

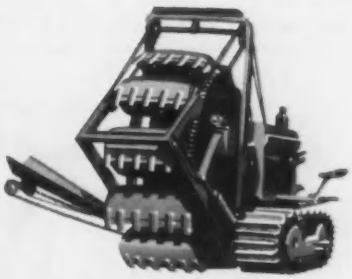
For more information—
Circle 40, inside back cover

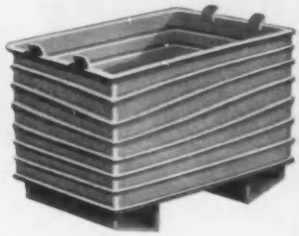
Standard Unit For Paris Escapement

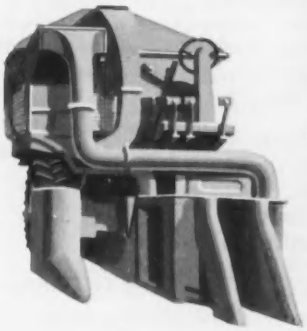
This escapement mechanism is designed to be attached at any point along the feed track. Spring-loaded fingers automatically release the individual parts. The escapement will not jam or damage piece parts. No

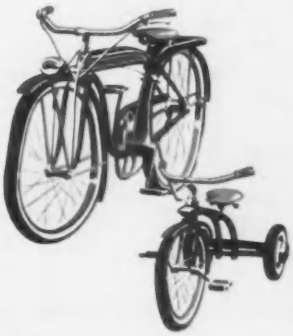
CONTINUED ON PAGE 240











MAKE IT WEIGH LESS

N·A·X

HIGH-TENSILE STEEL

MAKE IT LAST LONGER

You can design light weight, longer life, and economy into your products by including N-A-X HIGH-TENSILE in your plans.

- It is 50% stronger than mild steel.
- It is considerably more resistant to corrosion.
- It has greater paint adhesion with less undercoat corrosion.
- It has high fatigue life with great toughness.
- It has greater resistance to abrasion or wear.
- It is readily and easily welded by any process.
- It polishes to a high lustre at minimum cost.

And with all these physical advantages over mild carbon steel —it can be cold formed as readily into the most difficult shaped stamping.

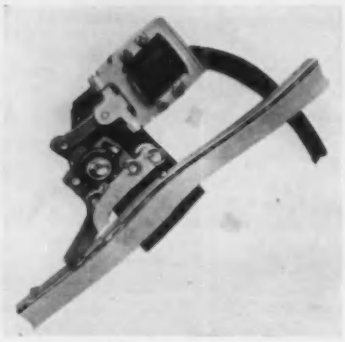
When you next start to redesign, get the facts on N-A-X HIGH-TENSILE. It's produced by Great Lakes Steel—long recognized specialists in flat-rolled steel products.

N-A-X Alloy Division

GREAT LAKES STEEL CORPORATION

Ecorse, Detroit 29, Mich. A Unit of

NATIONAL STEEL CORPORATION



special slots or track junctions are required. Models are available for solenoid or air cylinder operation.

This escapement will automatically release up to 200 parts per minute, one at a time. The escapement fingers can be shaped or formed to accommodate any piece part up to 3 in. dia. Dixon Automatic Tool, Inc., 2300-23 Ave., Rockford, Ill.

For more information—
Circle 41, inside back cover

Teflon Products

These products include all of the Teflon basic shapes such as rod, tube, sheet, slab and mechanical and electrical-grade Teflon tape. Stock items include V-rings, O-rings, gaskets and gasketing material. Balfor Industries, Inc., 1815 Webster Ave., New York 57, N. Y.

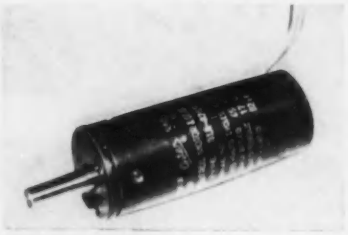
For more information—
Circle 42, inside back cover

Fhp Appliance Motor

An fhp motor, believed to be the first ever designed specifically for use on home laundry and electric sink appliances, has been announced. The new appliance motor is designed for use on washers, dryers, food waste disposers, dishwashers and ironers. Although completely interchangeable electrically and mechanically with the former design, the motor is said to be 24 per cent lighter, more compact, and ventilated by five times more air through the windings.

The new motor will be available for application on washers, dryers and dishwashers in ¼ and ½ hp ratings, with or without base, for horizontal or vertical mounting. For food waste disposers the motors will be available in a streamlined and totally enclosed shell for through-bolt mounting, less the pulley-end shield. Also available will be stator and rotor parts for built-in applications. General Electric Co., Schenectady 5, N. Y.

For more information—
Circle 43, inside back cover



Servo Gear Train

Size 11 servo gear train weighing 6.875 oz and consisting of a single homogeneous unit is now available. Type 2LR-3265 is designed to meet military requirements and can be built to operate in 150 C ambient. Both the motor section and the gear train section are extremely versatile and are designed to cover a range of applications. For example, the motor can be made to operate as a two, four, six or eight-pole motor. Windings can be made to operate on 60 or 400 cps, 26 to 115 v.

The gear train operates with load torques up to 25 in-oz. and maximum momentary load torques of 17 in-oz. Backlash is 35 min, min. John Oster Mfg. Co., Racine, Wis.

For more information—
Circle 44, inside back cover

Tachometer Has Overspeed And Underspeed Controls

This tachometer will not only indicate speed, but can also actuate self-contained power relays that signal overspeeds and underspeeds. It can be used in sounding alarms, turning on light signals, stopping or starting equipment, opening or closing valves,

controlling speeds or for many other similar applications where tachometers are likely to prove applicable.

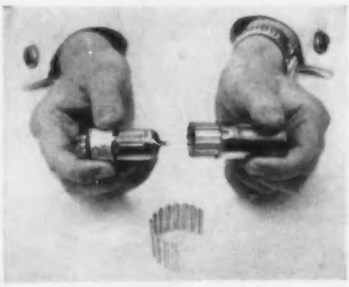
High and low limit pointers are independently adjustable. These pointers act as a single-pole, double-throw switch with the regular speed pointer acting as the switch center arm. A manual reset pushbutton is used to reset the tachometer after the relays have signaled a high or low speed.

This tachometer is available with any one of 48 different scales. Metron Instrument Co., 432 Lincoln St., Denver 3, Colo.

For more information—
Circle 45, inside back cover

Miniature Tube Cooling Device

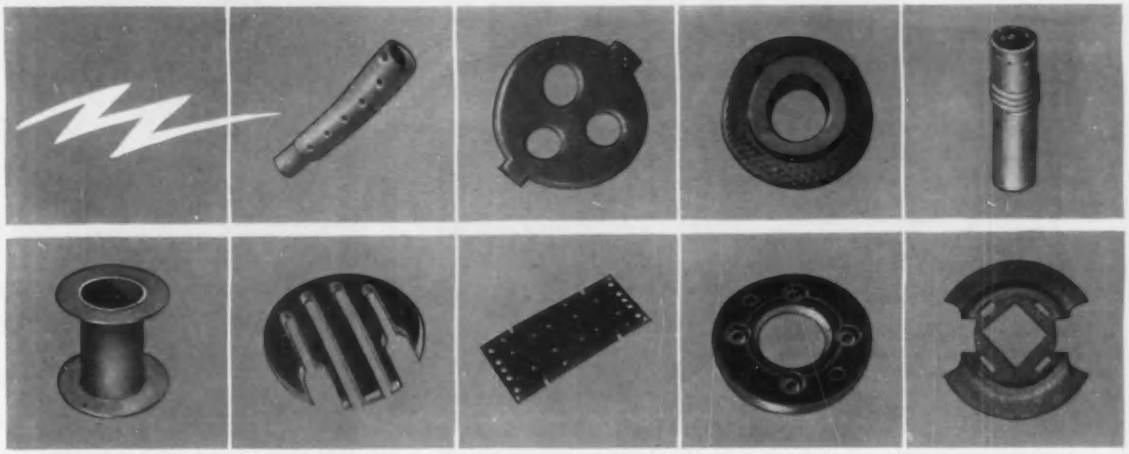
A bulb cooling device for miniature tubes using JAN shields consists of a corrugated strip of 0.003 in. cadmium-plated spring brass, with a black matte finish, which is formed into a cylinder and inserted into the JAN shield before it is placed over the tube. Due to the corrugations, the insert contacts



CONTINUED ON PAGE 242

HOW Spaulding PRODUCTS MEET YOUR REQUIREMENTS FOR EFFICIENT, LIGHT-WEIGHT

ELECTRICAL INSULATION



SPAULDING PRODUCTS have high dielectric strength, low loss factor, excellent arc resistance, deionizing properties, low heat conductivity, and moisture resistance.

THESE DESIRABLE electrical insulating characteristics may be had in a variety of combinations with chemical and mechanical properties such as light weight, resistance to wear and abrasion, dimensional stability, and chemical inertness.

CLEAN PUNCHING, clean machining, and good forming qualities permit Spaulding to work your exact specifications in fabricating even the most complicated shapes.

Consult your nearest Spaulding Branch Office for complete information.

SPAULDING FIBRE COMPANY, INC., TONAWANDA, N. Y.

MAKERS AND FABRICATORS OF:

VULCANIZED FIBRE: In sheets, rods, tubes and fabricated parts.

ARMITE: Thin insulation (Fish Paper) in sheets, rolls, coils and fabricated parts.

SPAULDITE: (Laminated Phenolic Plastic) in sheets, rods, tubes and fabricated parts.

SPAULDO: Motor insulation in sheets, rolls, coils, slot cells and other fabricated parts.

SPAULDING FIBRE BOARD: In sheets and fabricated parts.

SPAULDING T BOARD: A superior Transformer Board, in sheets and fabricated parts.

MATERIALS HANDLING EQUIPMENT: Factory trucks, Boxes, Barrels, Trays, etc.

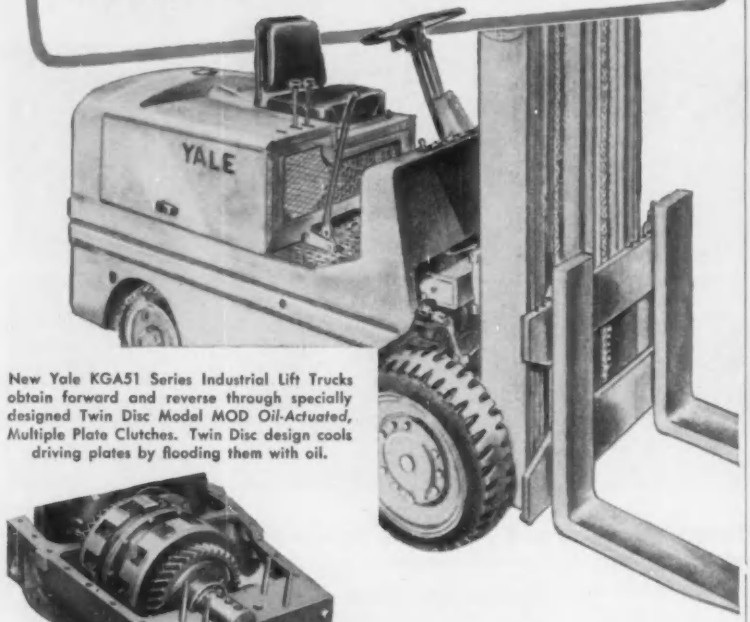
SPAULDING FABRICATING FACILITIES

Spaulding's fabricating facilities for these products are unsurpassed the world over. You can save time and money by letting us do your fabrication. We'll be glad to quote on specific jobs without obligation to you.

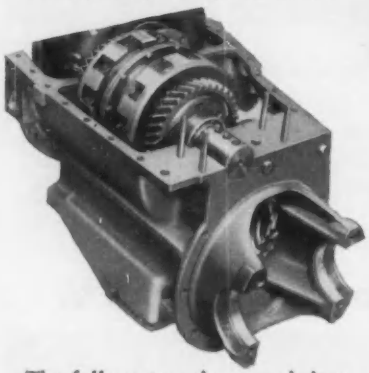
SPAULDING BRANCH SALES OFFICES

BALTIMORE 18, MD.
BOSTON 16, MASS.
BOSTON 82, MASS. (Wellesley Hills)
BRIDGEPORT 5, CONN.
CHICAGO 25, ILL.
CHICAGO 38, ILL.
CLEVELAND 14, OHIO
CLEVELAND 16, OHIO (Rocky River)
DAYTON 2, OHIO
DETROIT 1, MICH.
FORT WAYNE 6, IND.
LANSING 10, MICH.
LONG ISLAND, N. Y. (Woodhaven 21)
MILWAUKEE 8, WIS.
NEW YORK 55, N. Y.
NEWARK, N. J. (Westfield, N. J.)
PHILADELPHIA, PA. (Camden 1, N. J.)
ST. LOUIS 5, MO.
TONAWANDA, N. Y.
LOS ANGELES 15, CALIF. C. D. LaMaree
BERKELEY 10, CALIF. C. D. LaMaree
TORONTO 18, ONT. A. A. Andersen & Co.

Forward and reverse on new Yale KGA51 Series obtained by specially designed *TWIN DISC CLUTCHES*



New Yale KGA51 Series Industrial Lift Trucks obtain forward and reverse through specially designed Twin Disc Model MOD Oil-Actuated, Multiple Plate Clutches. Twin Disc design cools driving plates by flooding them with oil.



The fully automatic transmissions in the new Yale KGA51 Series Industrial Lift Trucks obtain forward and reverse motion through specially designed Twin Disc Model MOD *Oil-Actuated,* Multiple Plate Clutches.

Because of the severe energy cycle of the vehicle, a specific clutch for finger-tip control was required. Twin Disc Engineers *worked closely* with the manufacturer in developing such a clutch. In the special Twin Disc design, oil is pumped through the shaft and cools the driving plates *by flooding them with oil.* Sintered friction material is also used, because of the high energy loading.

If you have a specific power linkage problem, on your powered equipment, consult Twin Disc Specialists . . . ask them to assign you a project engineer. Twin Disc Clutch Company, Racine, Wisconsin.

TWIN DISC

TWIN DISC

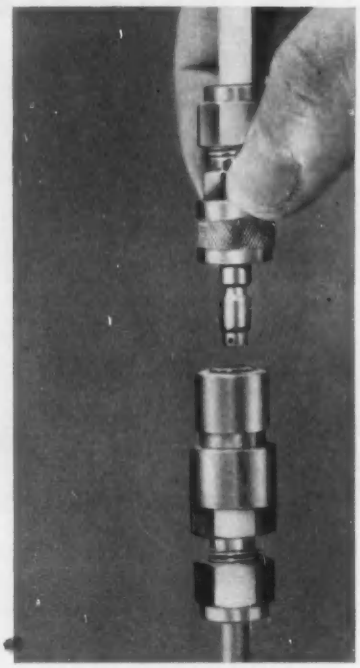
Friction Clutches and Fluid Drives

TWIN DISC CLUTCH COMPANY, Racine, Wisconsin • HYDRAULIC DIVISION, Rockford, Illinois

Branches or Sales Engineering Offices: Cleveland • Dallas • Detroit • Los Angeles • Newark • New Orleans • Tulsa

both tube and shield, allowing heat to flow through the shield and into the chassis. The insert is available in six sizes, to fit all 5½ and 6½ miniature envelopes. Birtcher Corp., 4371 Valley Blvd., Los Angeles 32, Calif.

For more information—
Circle 46, inside back cover



Quick-Connect Fitting

The shutoff valve incorporated in this fitting acts as a positive seal to prevent any leakage during the connecting or disconnecting operation. Used with plastic tubing and metal tubing, these quick-connects are available in all metals, in sizes to fit ordinary applications and in three types. Crawford Fitting Co., 884 E. 140 St., Cleveland 10, Ohio

For more information—
Circle 47, inside back cover

Pneumatic Disconnect Fitting

Pressure drop through this unit is said to be equivalent to that of a straight tubing section. When disconnected, the checked end serves as a bubbletight, leakproof shut-off valve.

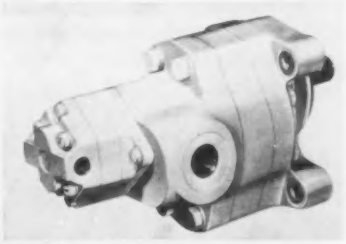
One-quarter turn by hand is re-

(Continued on page 243)

quired to connect or disconnect. No tools are needed. When disconnecting, the unique safety interlock automatically bleeds down trapped air, eliminating all danger to personnel. The unit can be disconnected or connected under pressure as high as 3000 psi.

This new pneumatic disconnect comes in ¼ and ⅜ in. sizes. Eastern Aircraft Products Corp., 229 River St., Orange, N. J.

For more information—
Circle 48, inside back cover



Tandem Pump

These pumps, when used in tandem, operate from a common driving medium, eliminating the cost of a second drive unit. This is accomplished by mating the shafts of the two pumps. A common inlet cuts the amount of hydraulic piping. Typical combinations of the tandem assembly range in length from 8⅝ to 10⅛ in.

Capacities of the tandem pump combinations range from 4.8 to 29.0 gpm at 1000 psi for the larger pump in 1750 rpm installations; from 1.0 to 4.0 gpm at 1000 psi for the smaller

(Continued on page 244)

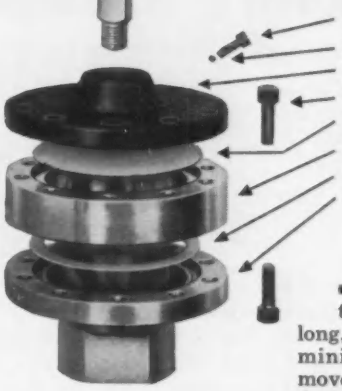
an ACCO product

Helicoid Chemical Gage

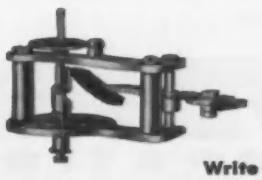
Gages for corrosive chemicals and liquids up to 5000 p.s.i.

• Here's an accurate pressure gage for chemicals and other viscous liquids which might corrode or clog the Bourdon Tube. It registers working pressures from 30″ vacuum to 5000 p.s.i. and temperatures to 400° F. Guaranteed accuracy plus or minus 1%. A single diaphragm seals off objectionable substances from the indicating gage. This gage is filled completely with specific inert liquids and pressure is transmitted directly to the indicating gage through deflection of the sealing diaphragm.

FEATURES



• HELICOID GAGES cost less in the long run because they give long, trouble-free service with a minimum of maintenance. The movement is a simple cam and roller design that does not have any gear teeth to wear out. It has been tested and proved in years of hard service.



Only Helicoid Pressure Gages Have the Helicoid Movement

Write for Catalog Today

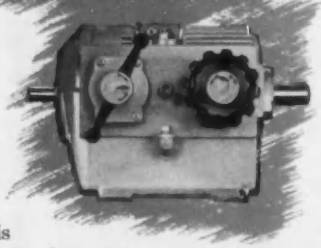
ACCO

Helicoid Gage Division
AMERICAN CHAIN & CABLE

929-D Connecticut Avenue • Bridgeport 2, Connecticut

Pressure • Vacuum • Compound

If you could hire a Gnu...



The ungainly Gnu is considered to be a most flexible beast. He has six speeds forward, can make prodigious leaps, can turn on a dime, and even back-up at an acceptable speed. However, the Gnu has to take a back seat in the flexibility department to the new GEROTOR VARIABLE SPEED HYDRAULIC TRANSMISSION. This new transmission has infinitely variable speeds—up to 1500 rpm—in *either* direction, can reverse itself instantly, has completely self-contained controls, can be mounted easily with standard motor to fit just about any situation. Better cancel your plans to hire the Gnu and make rapid inquiries about the new GEROTOR VARIABLE SPEED HYDRAULIC TRANSMISSION . . . *write:*

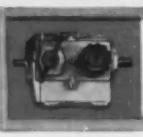
GEROTOR

MAY CORPORATION

MANUFACTURERS OF—

1511 MARYLAND AVENUE, BALTIMORE 3, MARYLAND

Hydraulic Pumps and Motors



Variable Speed Hydraulic Transmissions

PneuBin—Pneumatic Bin Evacuators

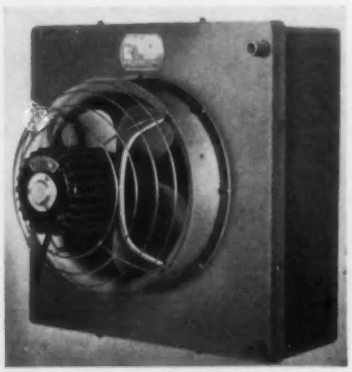
pump. The smaller pump normally is the one used in power steering installations. Webster Electric Co., Racine, Wis.

For more information—
Circle 49, inside back cover

Potentiometer ⅝ In. Dia.

This metal-housed, ⅜ oz potentiometer is available in single as well as multi-gang construction. They may be had with winding resistances from 20 to 30,000 ohm minimum resolution of 0.09 per cent and linearity of 0.25 per cent, where specified. The maximum continuous operating temperature is 150 C and the units meet applicable MIL-E 5272A specifications. Gamewell Co., Newton Upper Falls 64, Mass.

For more information—
Circle 50, inside back cover



Heat Exchanger

Recommended for use in closed-system liquid circuits, the heat exchanger has 3 kw capacity and finds application in radio transmitters, oscillators, dielectric heating apparatus and similar devices incorporating liquid-

(Continued on page 245)

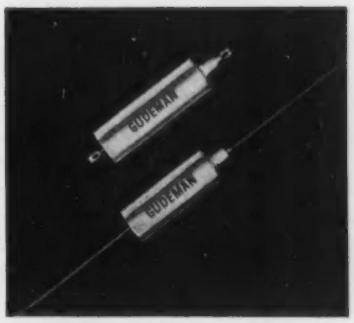
cooled vacuum tubes. The exchanger weighs 12 lb and is available in either Type 1-3000, having liquid flow capacity of 4 gpm or Type 2-3000, having liquid flow capacity of 8 gpm. The heat capacity is the same for each type. The fan motor is of the shaded-pole type and connects to a single-phase, 115-v, 60-cps supply line. Rotron Mfg. Co., Schoonmaker Lane, Woodstock, N. Y.

For more information—
Circle 51, inside back cover

Air Cylinder Exhaust Muffler

Made of non-corrosive materials throughout, the muffler consists of a series of perforated discs held between spacers in a compact cylinder only $\frac{13}{16}$ x $4\frac{5}{16}$ in. long overall. Body is tapped for $\frac{1}{8}$ in. female thread, and standard brass hex nipples are supplied to provide either $\frac{1}{4}$ or $\frac{3}{8}$ in. Modernair Corp., 400 Preda St., San Leandro, Calif.

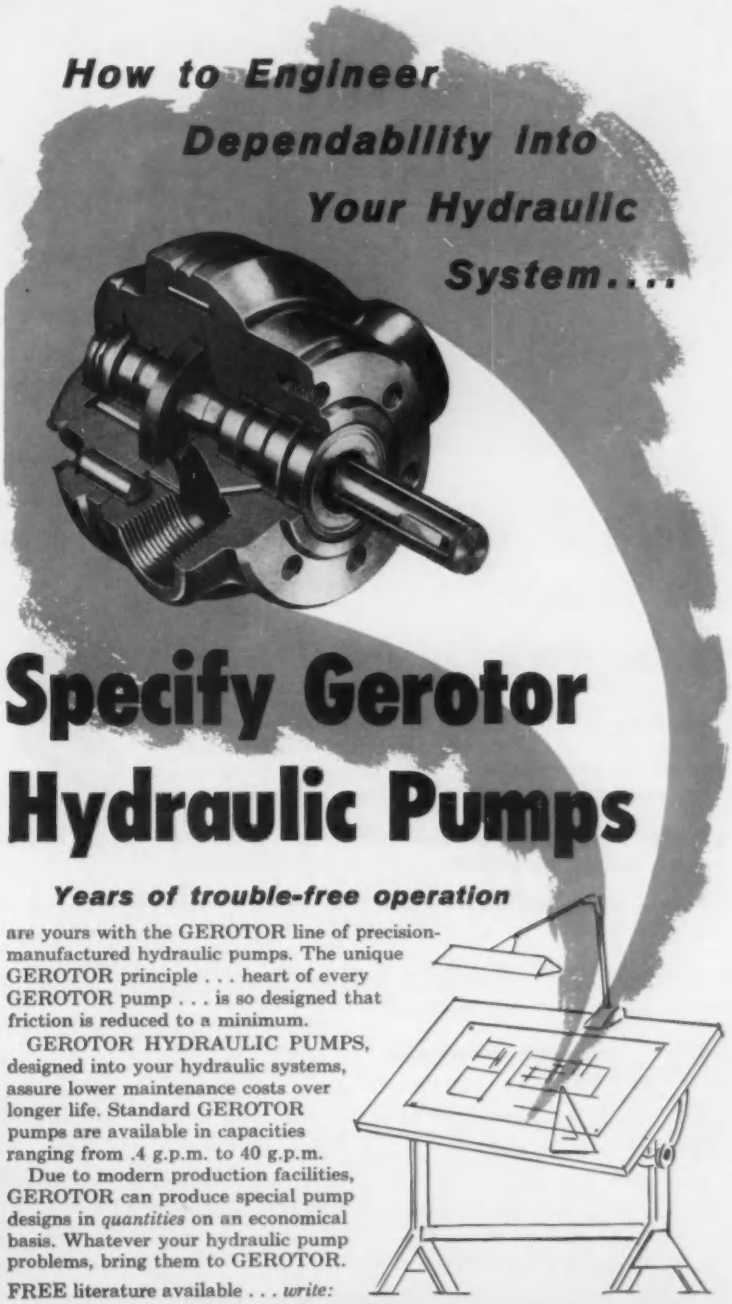
For more information—
Circle 52, inside back cover



Miniature Feed-Through Capacitors

A line of miniature paper dielectric hermetically sealed capacitors designed for use in rf interference sup-

(Continued on page 246)


How to Engineer
Dependability into
Your Hydraulic
System....
Specify Gerotor
Hydraulic Pumps
Years of trouble-free operation
are yours with the GEROTOR line of precision-manufactured hydraulic pumps. The unique GEROTOR principle . . . heart of every GEROTOR pump . . . is so designed that friction is reduced to a minimum.
GEROTOR HYDRAULIC PUMPS, designed into your hydraulic systems, assure lower maintenance costs over longer life. Standard GEROTOR pumps are available in capacities ranging from .4 g.p.m. to 40 g.p.m.
Due to modern production facilities, GEROTOR can produce special pump designs in *quantities* on an economical basis. Whatever your hydraulic pump problems, bring them to GEROTOR.
FREE literature available . . . *write:*
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MANUFACTURERS OF—
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get this KEY to lower assembly costs

There are new opportunities for cutting assembly costs in the "Key Locking" feature of KELOX Inserts and Studs. You can improve your product and reduce assembly costs with KELOX because these fasteners—

1. Provide a positive lock between insert or stud and parent body.
2. Provide higher stress allowable per space required.
3. Are simple to install and remove.
4. Make maximum use of tapped hole.
5. Afford considerable reduction in assembly weights.
6. Save space and improve product design.
7. Can be serviced in field without special tools.
8. Require no special threads.

KELOX Fasteners are part of a family of universally used PHILLIPS PRODUCTS that are designed, developed and distributed by a world-wide organization.

This highly specialized, technical group will be glad to assist you with your fastener problems. Use coupon below to get more facts on KELOX!

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Sturgis, Michigan

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Atlanta 3, Georgia

Monogram Manufacturing Co.
8557 Higuera Street
Culver City, California

D. R. & W. Technical Service Company
P. O. Box 4
East Hartford, Connecticut

Scott Fittings Limited
339 Bering Ave., P. O. Box 169
Toronto 18, Canada

3395

Please send me technical data on KELOX Inserts and Studs

Name ..... Title .....

Company .....

Address .....

Product being assembled .....

pression is now available. Operating temperature range is from −55 C to 85 C for Type 271 and from −55 C to 125 C for Type 272. Type 271 meets applicable environmental requirements of MIL-S-25A for characteristic E and Type 272 for characteristic K.

The 300 v, dc, units may be used at 150 v, ac, from 60 to 400 cps, and the 600 v, dc, units at 300 v, ac, from 60 to 400 cps. Both types withstand a d-c test voltage equal to twice rated d-c voltage or a 60-cps, a-c test voltage equal to twice the recommended a-c voltage rating for 2 min, max, when applied between case and either terminal. Gudeman Co., 340 W. Huron St., Chicago 10, Ill.

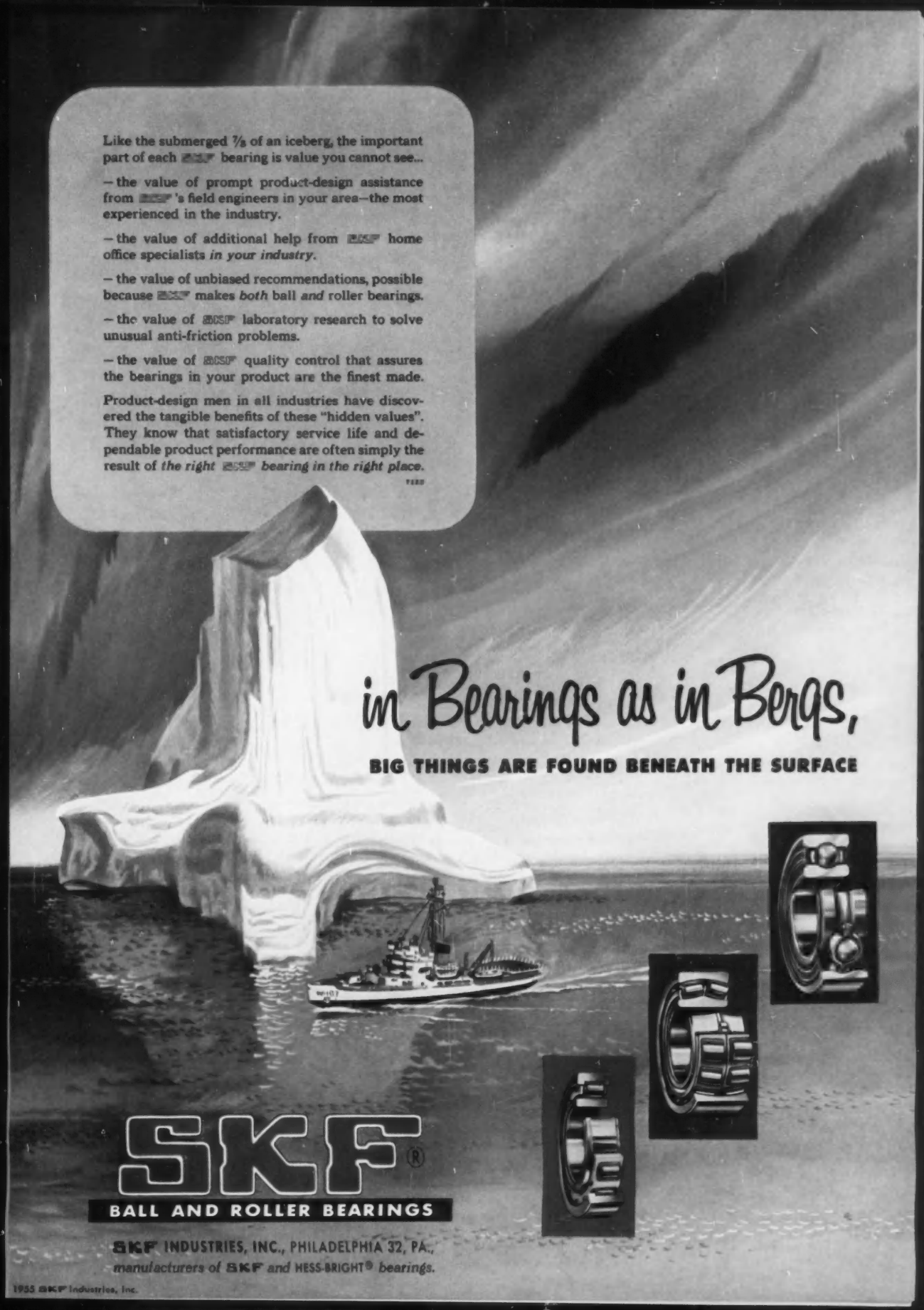
For more information—
Circle 53, inside back cover

Analog-Digital Converter

A lightweight, 13-channel encoder has been developed for reading shaft positions to an accuracy of one part in 8192. This instrument may be applied to a variety of purposes where the position of rotating shaft is required either as an input to some controlling device, or for real-time data reduction. The output of this converter is in cyclical-binary code, which may be recorded or otherwise processed in that form, or converted to some other form.

The converter employs no slip rings or moving contacts, no gears, and no circuits in which the accuracy of any one reading depends on that of a preceding reading. Instead, photoelectric means are employed to pick off shaft position with no frictional drag on the shaft. A glass disk is mounted directly on the shaft, and is very

(Continued on page 249)


Like the submerged 7/8 of an iceberg, the important part of each SKF bearing is value you cannot see...
– the value of prompt product-design assistance from SKF 's field engineers in your area—the most experienced in the industry.
– the value of additional help from SKF home office specialists *in your industry*.
– the value of unbiased recommendations, possible because SKF makes *both* ball *and* roller bearings.
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– the value of SKF quality control that assures the bearings in your product are the finest made.
Product-design men in all industries have discovered the tangible benefits of these "hidden values". They know that satisfactory service life and dependable product performance are often simply the result of *the right SKF bearing in the right place.*
in Bearings as in Bergs,
BIG THINGS ARE FOUND BENEATH THE SURFACE
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BALL AND ROLLER BEARINGS
SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.,
manufacturers of SKF *and* HESS-BRIGHT® *bearings.*
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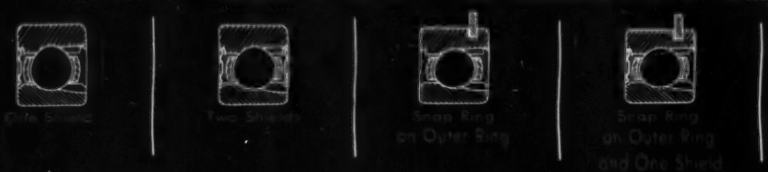
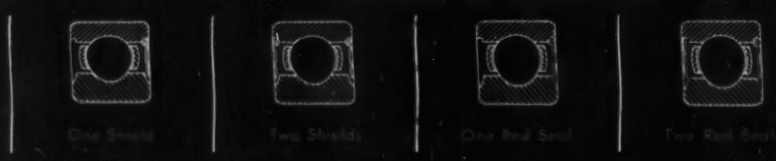
SKF
makes them all

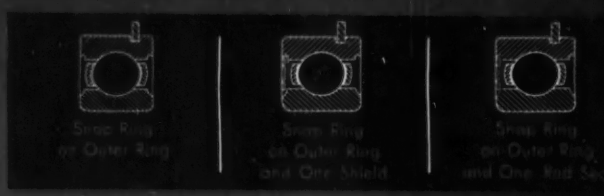
SKF's comprehensive line of Filling Slot and Deep Groove Ball Bearings (some of which are shown here) is typical of the complete bearing service which **SKF** provides. That is why you get unbiased advice based on exceptionally broad experience when **SKF**'s product-assistance staff helps you put the right bearing in the right place in your product.

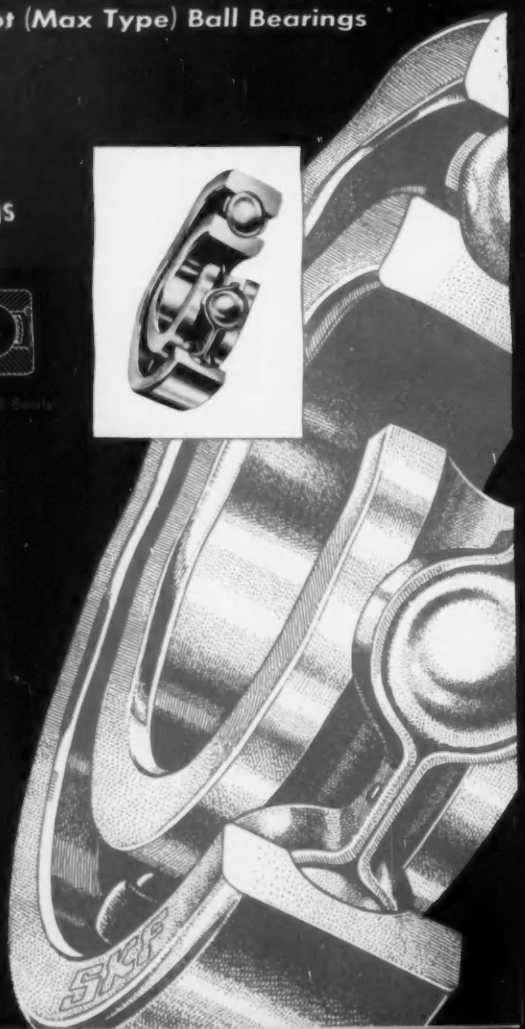


Single Row, Filling Slot (Max Type) Ball Bearings

Single Row, Deep Groove Ball Bearings







SKF®

BALL AND ROLLER BEARINGS

SKF INDUSTRIES, INC., PHILADELPHIA 32, PA.
manufacturers of **SKF** *and* HESS-BRIGHT® *bearings*

Form 419-5-55

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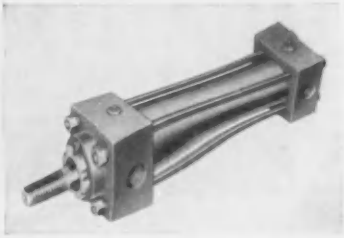
accurately scaled into a code of transparent and opaque areas. These areas constitute a pattern of 13 channels forming the cyclical binary code.

A very useful property of this code is that between successive angular positions of the disk there is a change in but one of the binary digits: hence, potential ambiguity or error of the readings cannot under any circumstances exceed one-half of one discrete position. Readout is made at any desired rate up to 100 per second. Electronics Corp. of America, 720 Beacon St., Boston, Mass.

For more information—
Circle 54, inside back cover



Heavy Duty Cylinders

Non-rotating, double-acting, square-end cylinders are available in five bore sizes, from 2 to 6 in.; pressures 150 psi air to 500 psi oil; five basic mounting styles—foot, trunnion, flange, clevis, pivot. Logansport Machine Co., Logansport, Ind.

For more information—
Circle 55, inside back cover

Hydraulic Power Unit

A complete hydraulic power unit, with 6 or 12-v d-c motor drive, pump, control valve and tank has been designed for applications on mobile equipment, such as snow plows, hoists, booms, tail gates. A rectangular housing of cast aluminum serves as the reservoir for 110 cu in. of oil. The

(Continued on page 252)

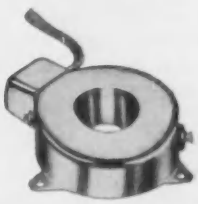
Are Your Components Guilty of RADIO NOISE?

POTTER *can tell you "why"*

POTTER *can tell you "how"*

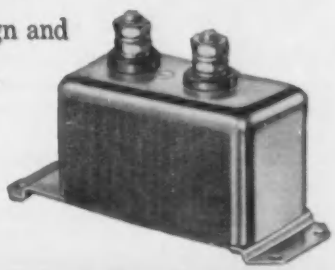
and **POTTER** *can make the* **FILTER** *that will confirm that "how"*

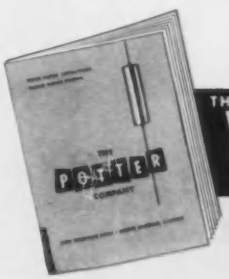
Once it's stated completely and correctly, a problem is half solved. Potter can put the facts and figures of your problem on paper . . . can chart its limits in laboratory tests . . . can engineer the solution. And Potter can embody that solution in subsequent design and production.



Call Potter to engineer, design and produce the filter to solve your radio interference problem.

Write for Bulletin 41 H.





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Looking For
LOW COST
Stainless Steel?

...then you want
MicroRold® 430 Sheet

Perhaps you have always thought of stainless steel as a luxury material and out of the question as far as your product is concerned . . . or maybe you have seriously considered using stainless steel only to find its cost prohibitive . . .

True, some grades of stainless steel are relatively expensive, but this is because they possess higher degrees of corrosion resistance, absolutely necessary in some highly corrosive applications. This is not the complete story, however, as there are other less expensive grades of stainless having sufficient corrosion resistance without sacrificing the other desirable stainless steel qualities of beauty, strength, long life, workability and ease of maintenance.

If extreme corrosion resistance is not a factor in your product, it would be unnecessary and costly to specify a higher grade of stainless than required.

This is where MicroRold 430 enters the profit picture...

MicroRold Type 430 is a straight chromium-stainless with a nominal composition of 17% chromium. Though it is less resistant to corrosion, it retains all of the other desirable qualities of stainless and has proven very satisfactory in a wide range of mild corrosion applications.

MicroRold 430 is the least expensive of our stainless types because it does not contain nickel. This results in a 7¾c per pound difference in base price between Type 430 and Type 302, the most popular higher grade stainless. A saving of $155 per ton is possible and is of merit to cost-conscious fabricators.

MicroRold Type 430 sheets are available in thicknesses .005" to .109" with 2B or 2D finishes; and in thicknesses .010" to .109" in No. 3, 4 and 7 finishes.

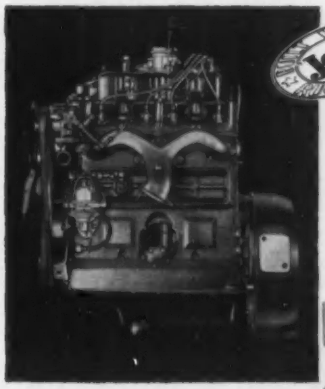
Send for your copy, "Care and Use of 430 Stainless"

Washington Steel
Corporation

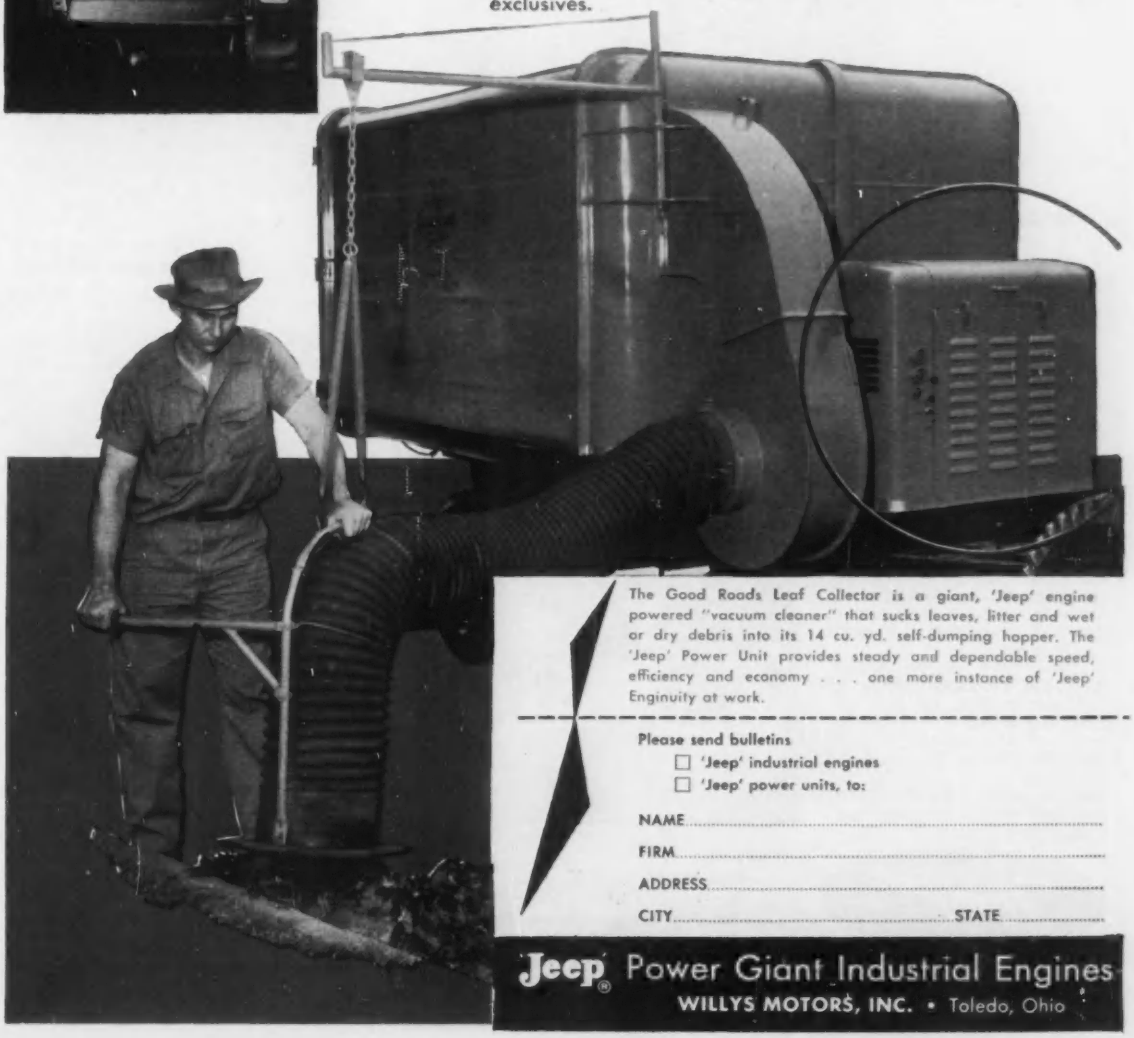
2-G WOODLAND AVE. WASHINGTON, PENNSYLVANIA

'Jeep' engines . . . combat proven for industry's mightiest demands!

All these proven 'Jeep' features for one of the longest-lived, most rugged four-cylinder Industrial Engines today!



It's the heart of a fighter, with a history of astounding staying power under back-breaking demands. Now this famous engine has been redesigned specifically for industrial needs. Here's why the 'Jeep' engine can do so much, and last so long, for so little expense, in your powered equipment: • Up to 70 hp in a 2-foot length; • Stellite valves with positive rotators; • Positive crankcase ventilation; • Large 2" intake valves in F-head design for extra breathing capacity, and countless other 'Jeep' exclusives.



The Good Roads Leaf Collector is a giant, 'Jeep' engine powered "vacuum cleaner" that sucks leaves, litter and wet or dry debris into its 14 cu. yd. self-dumping hopper. The 'Jeep' Power Unit provides steady and dependable speed, efficiency and economy . . . one more instance of 'Jeep' Enginuity at work.

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☐ 'Jeep' industrial engines

☐ 'Jeep' power units, to:

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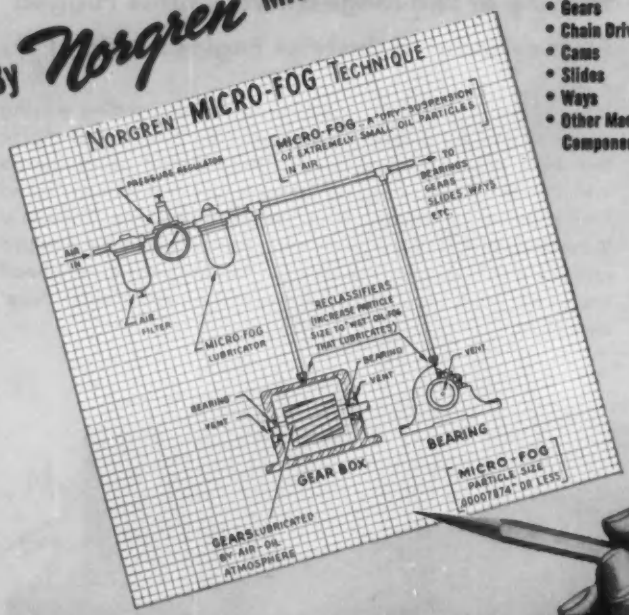
Jeep® Power Giant Industrial Engines

WILLYS MOTORS, INC. • Toledo, Ohio

MACHINE WEAR REDUCED TO A MINIMUM

By Norgren MICRO-FOG Lubrication

For
- Bearings
- Gears
- Chain Drives
- Cams
- Slides
- Ways
- Other Machine Components

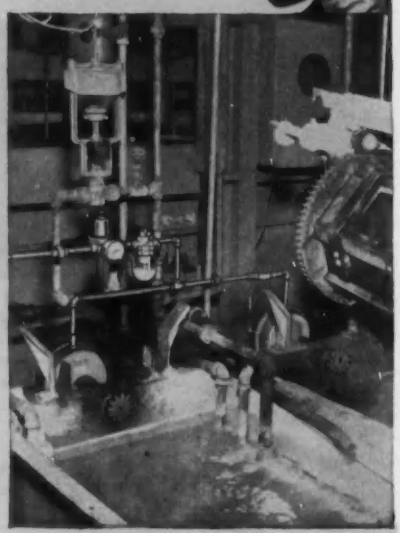

NORGREN MICRO-FOG TECHNIQUE
MICRO-FOG - A "DRY" SUSPENSION OF EXTREMELY SMALL OIL PARTICLES IN AIR
PRESSURE REGULATOR
AIR IN
AIR FILTER
MICRO FOG LUBRICATOR
TO BEARINGS GEARS SLIDES, WAYS ETC.
RECLASSIFIERS (INCREASE PARTICLE SIZE TO "WET" OIL FOG THAT LUBRICATES)
BEARING VENT
BEARING VENT
GEAR BOX
BEARING
MICRO-FOG PARTICLE SIZE .00007874" OR LESS
GEARS LUBRICATED BY AIR-OIL ATMOSPHERE

Norgren MICRO-FOG Ends Gear Lubrication Problem On Zinc Plating Tanks

At the Wagner Electric Corp., St. Louis, baskets containing parts to be zinc plated in a hot acid solution are mechanically agitated by a gear drive.

With the former drip feed lubrication method, acid fumes entered the gear boxes, contaminating the lubricant and destroying the gear box seals. Loss of lubricant plus corrosion by the contaminated lubricant greatly accelerated gear wear and resulted in frequent costly repairs.

Three years ago, the Norgren MICRO-FOG Lubrication System at right was installed. The gears are constantly protected from wear by a film of oil — and entry of acid fumes is prevented by the slight, continuous flow of air through the gear box, venting to the atmosphere. Gear wear and corrosion have been reduced to a minimum.



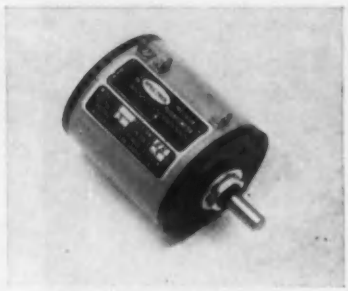
C.A. Norgren CO.

Write for
FREE BLUEPRINT MF-21
for complete details on this application — or call your nearby Norgren Representative listed in your telephone book.

3428 So. Elati, Englewood, Colo.
PRESSURE REGULATORS • AIR LINE FILTERS • LUBRICATORS • AIR CONTROL VALVES

electric motor is flange-mounted to one end of the housing and the pump control valve to the opposite end. All working parts are totally enclosed for full protection from outside elements. Wisconsin Hydraulics, Inc., 3165 N. 30 St., Milwaukee 16, Wis.

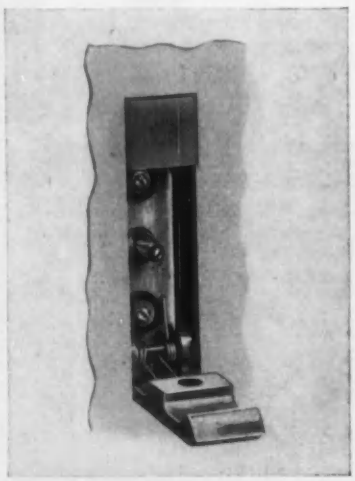
For more information— Circle 56, inside back cover



Ten-Turn Potentiometer

This 1⅛ in. potentiometer's standard linearity tolerances are 0.3 per cent; standard resistance tolerances are also 3 per cent. Spectrol Electronics, Div. of Carrier Corp., 1704 S. Del Mar Ave., San Gabriel, Calif.

For more information— Circle 57, inside back cover



Flush-Mounted Toggle Switch

These flush switch covers have been designed to provide access to a toggle switch which must be submerged and protected, on marine, aircraft, heavy automotive and material

(Continued on page 253)

handling equipment, or on electrical and electronic equipment where flush requirements are paramount. Trigger and cover are available in wide range of offsets to fit a variety of panel thicknesses. Simple pressure on trigger releases cover to open position, and pressure also latches it in closed position. When closed, the cover provides a self-contained switch guard (hole in back of latche for toggle) to prevent accidental actuation of switch from impact or shock.

Switches rated 10-20 amp, 125 v, ac, per pole. Up to four-pole, double-throw arrangements are possible. Hartwell Aviation Supply Co., 9035 Venice Blvd., Los Angeles 34, Calif.

For more information—
Circle 58, inside back cover

Gage Saver

This gage saver is designed for use in a hydraulic, fuel or pneumatic system having a maximum operating pressure of 10,000 psi. It is readily available for all shut-off pressures from 50 to 5000 psi. Standard units, with ¼ in. NPT gage connection and ¼ in. NPT or AN inlet connection are available from the manufacturer in either aluminum or stainless steel. Fisher Controls Co., 1222 Seventh St., Santa Monica, Calif.

For more information—
Circle 59, inside back cover

Fan Ventilates and Seals Automatically

Spring-loaded iris-type fins automatically seal the ventilator when power is turned off. Currently the blower is available in two models: the A398 which delivers 70 cfm at 5 in. of water and the A447, 600 cfm at 8 in. of water. The blowers require no additional envelope apart from duct

(Continued on page 256)

Norgren MICRO-FOG LUBRICATORS

with Maximum Capacities of 32, 200, 300 and 1000 Bearing Inches*

for BEARINGS • GEARS • CHAINS SLIDES • CAMS • WAYS OTHER MACHINE COMPONENTS

The Most Complete Equipment Line for Effective Lubrication.

⅓ Pt. Oil Capacity

Model 30-40-2S — ¼" pipe size. 32 Bearing Inch Capacity.
Model 30-40-3S — ⅜" pipe size. 32 Bearing Inch Capacity.

½ Pt. Oil Capacity

Model 30-41-2S — ¼" pipe size. 32 Bearing Inch Capacity.

1 Qt. Oil Capacity

Model S3406-2S —¼" pipe size. 32 Bearing Inch Capacity.
Model S3406-6S —¾" pipe size. 200 Bearing Inch Capacity.
Model S3406-8S —1" pipe size. 300 Bearing Inch Capacity.

1¾ Gal. Oil Capacity

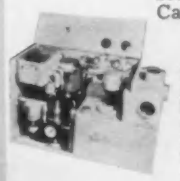
Model X3400-2S — ¼" pipe size. 32 Bearing Inch Capacity.
Model X3400-6S — ¾" pipe size. 200 Bearing Inch Capacity.
Model X3400-8S — 1" pipe size. 300 Bearing Inch Capacity.

4½ Gal. Oil Capacity

Model Y3400-2S —¼" pipe size. 32 Bearing Inch Capacity.
Model Y3400-6S —¾" pipe size. 200 Bearing Inch Capacity.
Model Y3400-8S —1" pipe size. 300 Bearing Inch Capacity.

Model 33AB-4

½" Inlet, 2" Outlet. 1000 Bearing Inch Capacity.



*For complete data on bearing inch ratings and applications, write for Norgren Blueprints MF-10 and MF-20.

C.A. Norgren CO.
3428 So. Elati St., Englewood, Colo.

Without obligation, learn how Norgren MICRO-FOG Lubricators can provide more efficient lubrication and reduce costs in your plant. Call your nearby Norgren Representative listed in your telephone directory—or WRITE THE FACTORY FOR NEW No. 700 CATALOG.

Pioneer and Leader in Oil-Fog Lubrication Since 1930

Withstands far greater

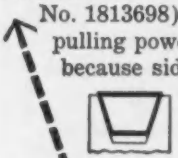
SHOCK LOADS

than any standard V-belt

Here are the interesting reasons why Gates Super Vulco Ropes stand up months, even years longer than *any* standard V-belts...

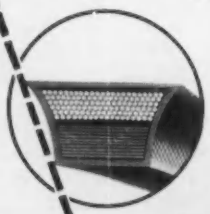
1. *Super-Strength Cords* provide 40% greater horsepower capacity . . . easily absorb heavy shock loads. **2.** *Flex-Weave Cover* (U.S. Pat. No. 2519590) provides greater flexibility with far less stress on the fabric. Cover wears longer — increases belt life, lowers belt costs.

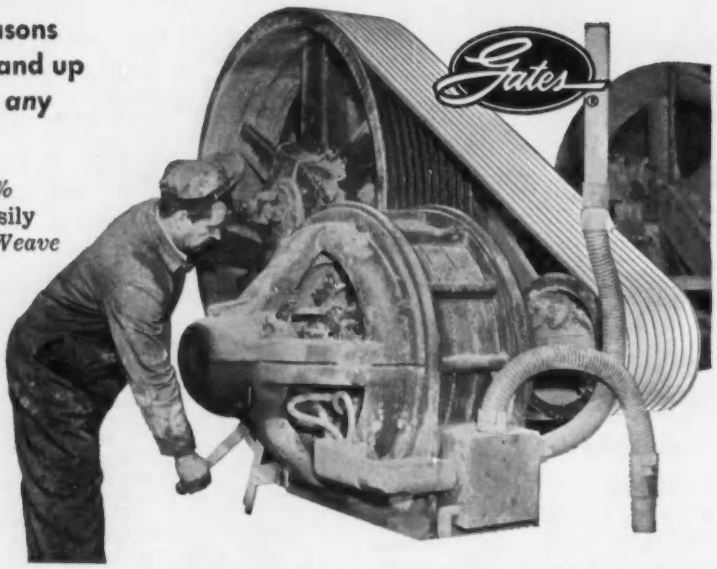
3. *Concave Sidewalls* (U.S. Pat. No. 1813698) provides sure pulling power, longer wear because sides straighten out as belt bends— make even contact with sheave walls.



Straight-sided belts bulge out when bent around sheave

Uneven contact causes uneven wear.





SHOCK LOAD of this big jaw crusher at Canadian Quarries, Ltd. is absorbed by Gates Super Vulco Rope Drive. Wherever shock load is severe, Gates Super Vulco Ropes cushion the shock—keep machinery replacement cost down.

3 other outstanding advantages

Resists Oil, Heat and Weather: Long life is assured even in the presence of excessive oil . . . even under prolonged exposure to heat and weather.

Provides Static Safety: The high electrical conductivity of Gates Super Vulco Rope provides safer drives in explosive atmosphere.

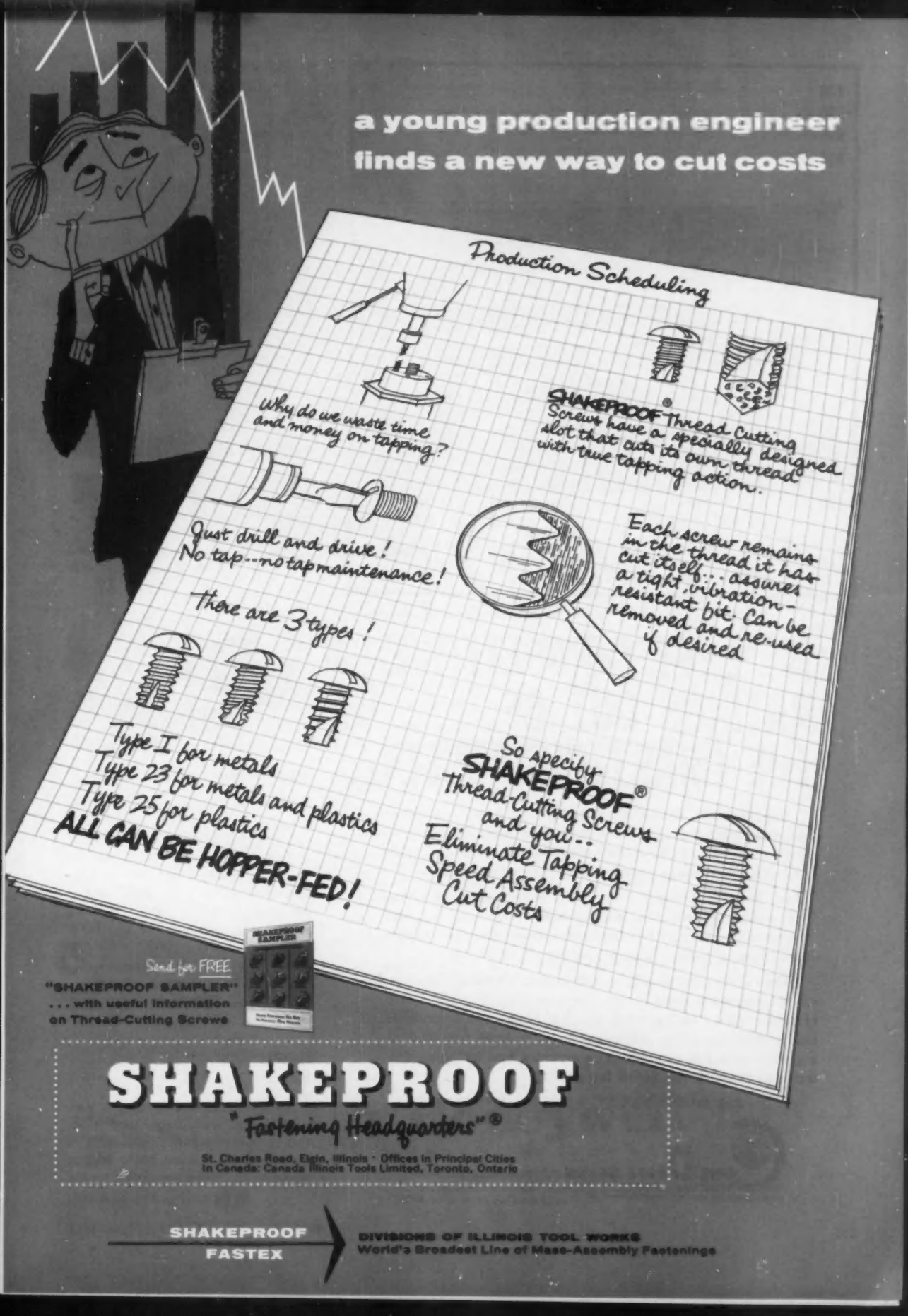
Saves Space: Higher horsepower rating and greater resiliency may permit fewer belts, or smaller sheaves where space saving is vitally important.

The Gates Rubber Co., Denver, Colorado
World's Largest Maker of V-Belts

Gates SUPER Vulco Rope

The V-Belt with 40% more horsepower capacity

TPA 57


a young production engineer
finds a new way to cut costs
Production Scheduling
Why do we waste time and money on tapping?
SHAKEPROOF® Thread Cutting Screws have a specially designed slot that cuts its own thread with true tapping action.
Just drill and drive! No tap--no tap maintenance!
Each screw remains in the thread it has cut itself... assures a tight, vibration-resistant bit. Can be removed and re-used if desired
There are 3 types!
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Type 23 for metals and plastics
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ALL CAN BE HOPPER-FED!
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Speed Assembly
Cut Costs
Send for FREE
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. . . with useful information on Thread-Cutting Screws
SHAKEPROOF
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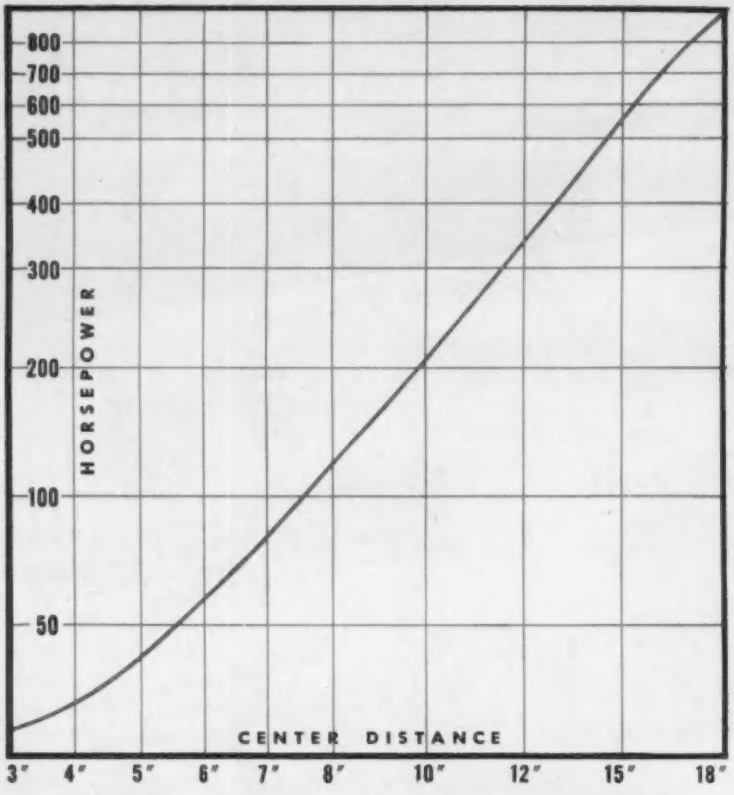
FASTEX
DIVISIONS OF ILLINOIS TOOL WORKS
World's Broadest Line of Mass-Assembly Fastenings



WE LEFT COMPETITIVE RATINGS OUT OF THE CHART PURPOSELY..

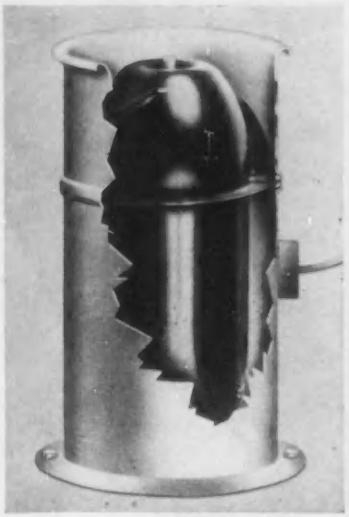
. . . because we think the load-carrying capacity of Cone-Drive speed reducers is pretty impressive all by itself. Then, we've also got a lot of friends in the worm gear speed reducer business. And they make pretty fair reducers themselves.

Two things are responsible for the high capacity of Cone-Drive speed reducers. First, we use extra-heavy gears mounted on oversize taper roller bearings in reinforced, heavy housings. Extra "beef' alone accounts for part of our capacity.

Even more important, however, is the Cone-Drive double-enveloping worm gear design. Here, we literally wrap worm and gear around each other to put ⅛ of all teeth in continuous full-depth contact. This results in spreading tooth contact over a greater area, reducing pressure on individual teeth, increasing load capacity and life of the gearing.

Ask for Bulletin 600C without obligation.

CONE-DRIVE GEARS Division, Michigan Tool Company
DOUBLE ENVELOPING GEAR SETS & SPEED REDUCERS
7171 E. McNichols Road • Detroit 12, Michigan



diameter. The valve mechanism needs only 1 in. space axially. Lundy Mfg. Corp., 36-08 33 St., Long Island City, N. Y.

For more information—
Circle 60, inside back cover

Silicon Power Transistors

The Type 970 silicon power transistor with a maximum power dissipation of 3.5 w at the temperature of boiling water weighs less than ¾ oz and is hermetically sealed in a disc approximately ½x½ in. high. Power dissipation is 8.75 w, max, at 25 C, with 3.5 w, max, at 100 C. Texas Instruments, Inc., 6000 Lemmon Ave., Dallas 9, Texas

For more information—
Circle 61, inside back cover

Rotary Solenoids With Return Springs

An adjustable return spring is now available on two basic models of this company's rotary solenoids. The spring permits minute spring torsion adjustments. Any return spring torque

(Continued on page 260)

NEW *Ambi-stat* temperature controller could be just what your product needs

It's ambient-compensated... compact... economical

Been looking for a temperature controller . . . in the low-cost bracket . . . that won't be bothered by changes in ambient temperature?

Here it is—the new Honeywell *Ambi-stat*. It's the ideal way to control temperatures in such equipment as bulk milk tanks, dry cleaning washers, vending machines, dishwashers, chicken scalders. It makes a highly dependable alarm . . . for high temperatures, or for frost.

New dependability. For the first time in a low-priced control, you get accurate control action regardless of ambient temperatures.

New versatility. Models are available for either heating or cooling applications . . . single or double-throw switching . . . temperatures 0—70 F or 40—180 F . . . nominal differential 2 F or 5 F.

Snap-action switching assures precise, sharp control at the set point. The small bulb . . . $\frac{3}{8}$" in diameter by $3\frac{1}{8}$" long . . . fits readily into your own product design. The complete controller is small, compact, easily mounted on practically any equipment.

REFERENCE DATA:
Write for Specification Sheet No. 866, "Honeywell *Ambi-stat* Remote Bulb Temperature Controllers."

Get complete data, consultation on application, and prices from your local Honeywell sales engineer . . . he's as near as your phone.

MINNEAPOLIS-HONEYWELL REGULATOR CO., *Industrial Division*, Wayne and Windrim Avenues, Philadelphia 44, Pa.—in Canada, Toronto 17, Ontario.

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BROWN INSTRUMENTS

First in Controls

Bonding rubber to nylon is one of PHOENIX' specialties

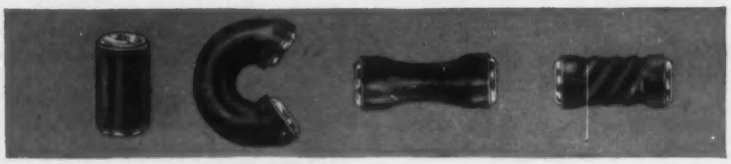
We are unusually successful at bonding natural and synthetic rubber to nylon. For example, with the flexible coupling shown below, the rubber will actually rupture before bond failure.

When you work with PHOENIX you have twenty years' experience in developmental work at your disposal. Quality control is of the utmost importance at PHOENIX. Modern laboratory facilities and exacting production control methods assure the closest of tolerances.

It is PHOENIX' practice to work in strictest confidence with our customers. Whatever rubber molding problems you may have, call on us. We are here to serve you.

Please address all inquiries to Rubber Products Division.

PUTTING THIS FLEXIBLE RUBBER-NYLON COUPLING THROUGH THE PACES. TESTING ITS "BEND," TENSILE STRENGTH AND TORQUE.



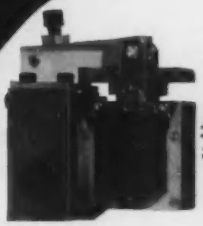
PHOENIX should be your source for custom rubber molding

PHOENIX MANUFACTURING COMPANY

RUBBER PRODUCTS DIVISION — JOLIET, ILLINOIS

CONTROLS YOU CAN depend on

WATERMAN CONTROLS
for accuracy—dependability
safety—low maintenance cost



SOLENOID VALVES

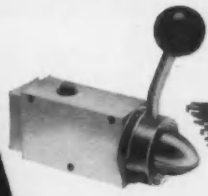
For working pressures to 3000 psi. Remote control of hydraulic systems for handling non-corrosive fluids.

LOOK TO WATERMAN

MICRONIC LINE FILTERS

Operating pressures to 3000 psi. 40 micron filtration. Replaceable elements. Available in ⅜" and ¾" NPT.

FOR THE ANSWER TO



ADJUSTABLE FLOW REGULATORS

Full range from 0.5 GPM to 20 GPM. All Waterman Flow Regulators maintain a constant rate of flow regardless of work resistance or pressure fluctuations.

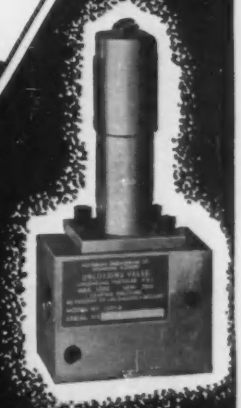
YOUR FLOW CONTROL

CHECK VALVES

One piece. Leak proof. Nylon Poppet. Aluminum body. Low pressure drop.

REQUIREMENTS

Write for bulletin of any of these products



UNLOADING VALVES

UNLOADING VALVES for system pressures to 3000 psi. Flow rates to 30 G.P.M. Fast acting, easily adjustable, maintain desired pressure settings without continuous readjustment. Hardened poppets eliminate leakage. Large passages assure maximum flow with minimum pressure loss.

WATERMAN ENGINEERING COMPANY

725 CUSTER AVENUE • EVANSTON, ILLINOIS

CARBON SOLVES DESIGN, ENGINEERING, AND PRODUCTION PROBLEMS

Light weight, corrosion-proof CARBON PUMP VANES

Vanes of Stackpole carbon-graphite for automotive rotating pumps are low in cost, light in weight and are made to close tolerances. Thanks to their chemical inertness, self-lubricating qualities and other factors, they are ideally suited for pumping air, corrosive chemicals or gases.

OIL SEALS that minimize pitting and blistering

Molded from carbon and graphite sometimes balanced with resins or metal powders to meet specific operating requirements, Stackpole seal rings are available in grades, types and sizes for almost any need. Recently developed grades greatly minimize pitting and blistering.

CARBON RODS for salt bath rectification

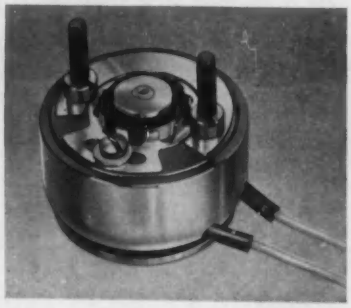
Stackpole rods are highly effective in avoiding decarburization of metal in heat treating by electric salt baths. Furnace electrode life is increased 4 to 6 times. Sludge formation and salt "drag out" are minimized. Greater fluidity of bath assures much faster, completely uniform heating.

THIS IS OUR 50th Year STACKPOLE FOUNDED 1906

STACKPOLE CARBON COMPANY
St. Marys, Pa.

STACKPOLE

Quality Products—backed by the keen personal interest and cooperation of the specialists who engineer them



can be set within the limits of the spring design. G. H. Leland, Inc., 123 Webster St., Dayton, Ohio

For more information—
Circle 62, inside back cover

Rotary Pressure Joint

This rotary joint is 1½ in. pipe size, designed to convey liquids or gases from a stationary pipe outlet to a revolving cylinder, drum, calender, dry can. This rotary is equipped with two ball bearings to support and guide axially the revolving shaft. A tamperproof metal seal is provided. Seamlex Company Inc., 41-23 24 St., Long Island City 1, N. Y.

For more information—
Circle 63, inside back cover

Shock-Resistant Rheostat

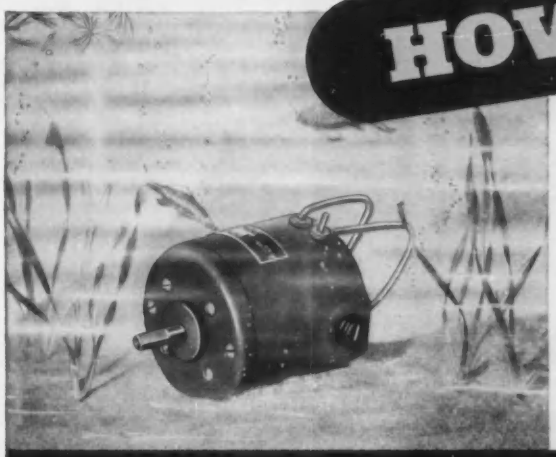
A 50-w ring-type rheostat designed specifically for use in electronic and industrial control equipment where severe mechanical shock is encountered is designed to meet requirements of MIL-R-15109 and of MIL-S-901. Base, core and collector ring support assemblies are made of glass-bonded mica. The toroidally core-wound resistance wire is secured with a silicone compound, separating the turns and protecting the wire. Balanced "twin contact" shoe construc-

(Continued on page 262)

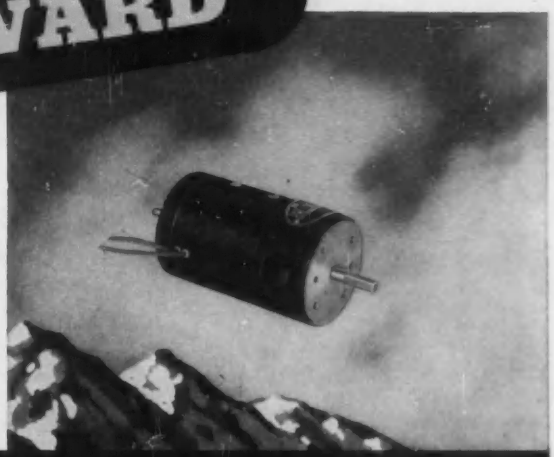
For extreme operating conditions

CHECK YOUR FRACTIONAL H. P. MOTOR APPLICATIONS WITH

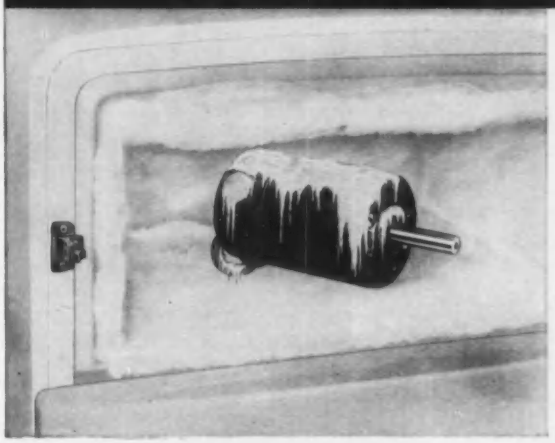
HOWARD



UNDER WATER



AT HIGH ALTITUDES



EXTREME COLD

EXTREME HEAT

Have a difficult fractional h.p. motor problem? Why not check with fractional h.p. motor specialists? Whether it be a problem of waterproofing, altitude, cold, heat, extreme quiet operation, long life or other exacting conditions, Howard has the motor to fill your need.

You'll find that Howard makes the most complete line of **fractional h.p. motors in the entire industry—Universal, Direct Current, Shaded Pole, Induction and Servo Motor types as well as gear motors and blowers in ratings from 1/2000 to 1/2 h.p.**

If you use fractional h.p. motors in your products, be sure to check with Howard. Write, wire or phone Racine 2-2731.

Now Safer than a Bond in the United States Defense Bonds

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DIVISIONS: EMC ELECTRIC MOTOR CORPORATION · CYCLOHM MOTOR CORPORATION · RACINE ELECTRIC PRODUCTS

HAGEN
Synchronous motors

Speeds of 1800 to 1/6 R P M

Single direction — Reversible

Here is the most powerful, compact synchronous motor for its size. Ideal for use in industrial applications that require a motor of overall size that is between the "clock" and fractional horsepower types.

Hagen Synchronous Motors are precision built throughout. Construction features a die cast housing, hobbed pinions and gears and bronze bearings throughout. Laminated rotor construction produces exceptionally high torque.

Hagen Synchronous Motors are available in five models. Standard motors may be mounted in any position. Coils are available for 24, 115, 230, 440 and 550 volts. Write for complete descriptive literature and performance data.

HIGHLY DESIRABLE FOR USE IN:

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CHART DRIVES
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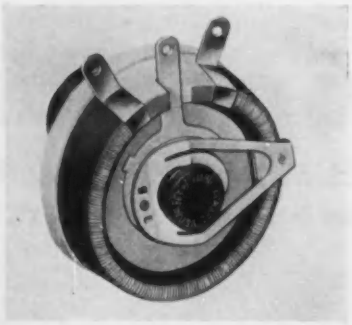
NAME AND TITLE

COMPANY

ADDRESS

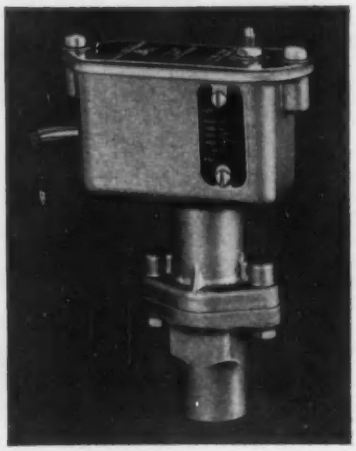
CITY ZONE STATE



tion eliminates backlash and assures smooth, positive control.

Rating of the rheostat is for 50 w continuous duty; standard resistance tolerance +20, −10 per cent; maximum resistance value, 20,000 ohm. Ward Leonard Electric Co., Mount Vernon, N. Y.

For more information—
Circle 64, inside back cover



Pressure Switch Visually Set

This switch has a calibrated plate which permits visual setting before or after installation on a pressure line. A tamperproof indicator inside is visible through a window in the plate. By means of an external adjustment screw, the indicator can be lined up with the desired pressure on the plate. Once the desired pressure is set, the screw can be locked in place to avoid accidental disturbance.

This switch senses any system pressure over an adjustable range of 15

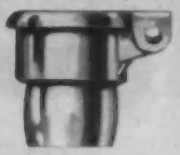
(Continued on page 266)

Here's How

GITS

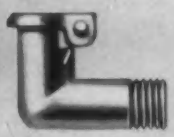
Helps Give

Built-In Low Cost To YOUR Equipment



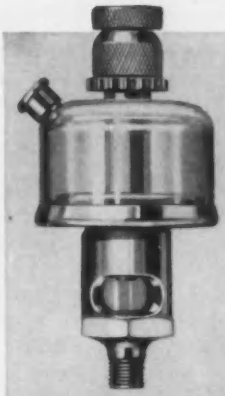
OIL HOLE COVERS

This model is designed to fit into a simple drilled hole. Ideal for use on small motors, generators, starters and light machinery—for dependable oil hole protection at moderate cost. Larger sizes frequently used as filler caps on tanks or reservoirs. Style R—No. 305.



OIL CUPS

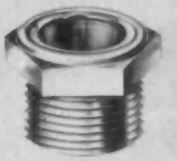
Accurately machined from a solid brass one-piece forging, this oil cup permits safe, dependable application of lubricant at very low cost. Used widely on motors and small machinery requiring side oiling. Style L—No. 1202.



SIGHT GRAVITY FEED OILERS

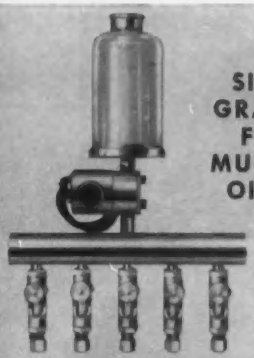
Rate of oil flow regulated by needle valve, directly observed through sight glass in stem.

Shut-off knob does not affect needle valve adjustment. Visible oil supply. Non-breakable. Tops in convenience and dependability, at low cost. Style NFU—No. 3602-A.



GEAR CASE GAUGES

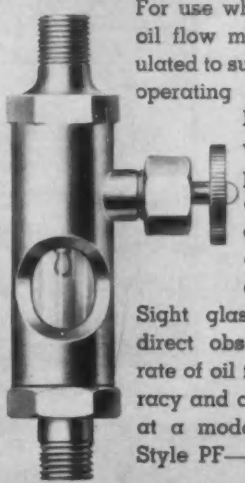
This oil gauge plug permits instant checking of oil level within a transmission or gear case. For use where construction permits insertion in tapped hole. A valuable addition to any such equipment — at very low cost. Style BW—No. 4042.



SIGHT GRAVITY FEED MULTIPLE OILERS

This one unit replaces 3 to 8 individual oilers. Maximum practicality in a small central lubrication system. Positive cut-off during idle periods. Individual vibration-proof needle valve adjustments. With solenoid control (Illustrated): Style MDS—No. 4685-A. Without solenoid: Style MD.

SIGHT GAUGES



For use where rate of oil flow must be regulated to suit changing operating conditions. Needle valve permits extremely accurate adjustment of oil feed. Sight glass provides direct observation of rate of oil flow. Accuracy and convenience at a moderate price. Style PF—No. 4290.

Don't price yourself out of the market. When you design proper lubrication into your equipment, specify GITS Lubricating Devices—the widest selection available anywhere. The items pictured above are only a few of our many thousands of lubricating devices. At the design stage, get the GITS story. Free Engineering Service. Send NOW for your free Catalog.

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Chicago 23, Illinois

Clip this page for handy "rough reference"

The world's largest opens a new era of

ABOUT one year ago, the largest die-casting machine in the world was completed and put into operation by Doehler-Jarvis Division of National Lead Company in cooperation with Kaiser Aluminum & Chemical Corporation.

Recently, the huge machine successfully produced the largest aluminum die-casting ever made—a six-cylinder in-line engine block weighing about 130 pounds less than a similar gray iron block.

The successful production of such a large and complex die-casting points the way to the design of large and economical die-cast aluminum parts for many industries.

Such parts would benefit from all the advantages of the die-casting process, which is inherently suited for mass production of parts requiring close dimensional tolerances, smooth surfaces, clean and sharp detail and thin metal sections.

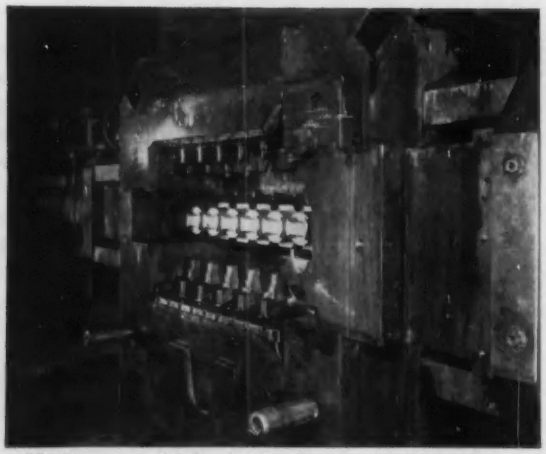
It is also possible to cast many details to size on the large press. In many cases, this eliminates the need to drill holes and other machining operations. Threads may often be cast to size, thus eliminating a threading operation. Cast-in metal inserts are readily included in die-castings.

Overall dimensional accuracy is another feature of die-castings that is important to many parts. This reduces the amount of finish allowance when parts are machined to a prescribed overall dimension.

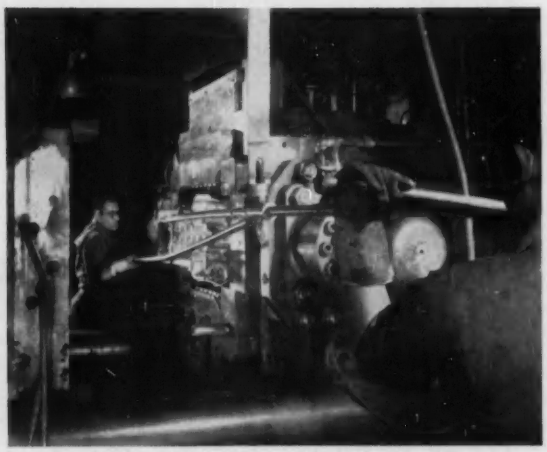
In addition, die-castings are generally lighter in weight than the equivalent parts made in sand or permanent mold, because thinner metal sections and less draft are permissible.

The metal quality of die-casting is more uniform than in a typical sand casting. Therefore, service life is more uniform.

Product designers and engineers should investigate this new Doehler-Jarvis Division of National Lead development in aluminum die-casting without delay to see if your existing or new designs can take advantage of the new 72″ machine.

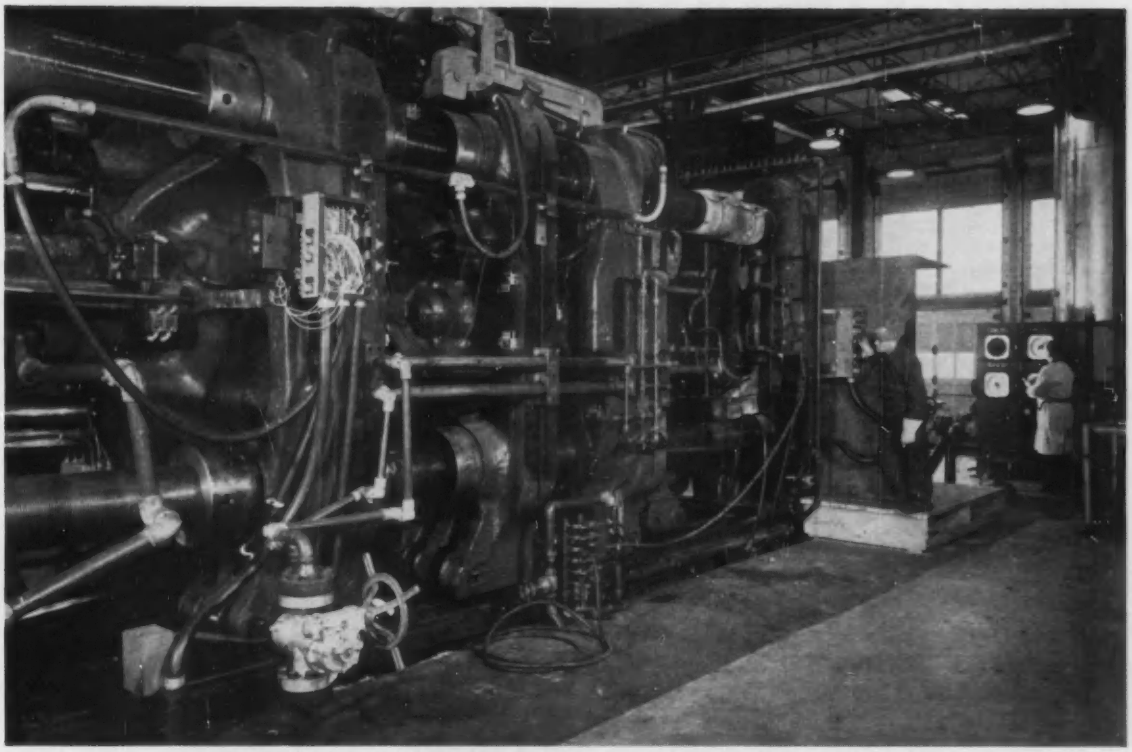


Machine open with dies for aluminum engine block in place.



Aluminum engine block being lifted from die after cast.

die-casting machine product design!



The new Doehler-Jarvis 72" die-casting machine—the world's largest—located at Toledo Plant.

Engine blocks were die cast by Doehler-Jarvis.

If you need assistance with aluminum . . .

Let us work in partnership with you. We are eager to share our knowledge of aluminum and engineering skill. Development engineers will gladly provide engineering service and counsel on design and alloy selection which may give you a better product at a lower cost. Kaiser Aluminum & Chemical Sales, Inc., *General Sales Office*, Palmolive Bldg., Chicago 11, Illinois; *Executive Office*, Kaiser Bldg., Oakland 12, California; DETROIT OFFICE, *1414 Fisher Bldg., Detroit 2, Michigan, Phone Trinity 3-8000.*

Kaiser Aluminum

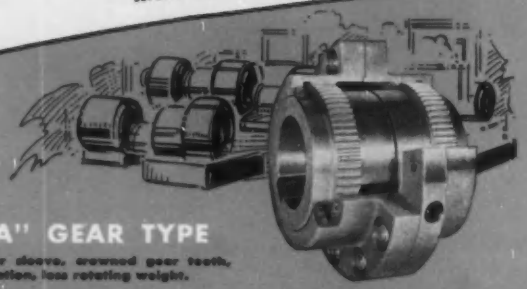
setting the pace—in growth, quality and service

WALDRON

built for long life

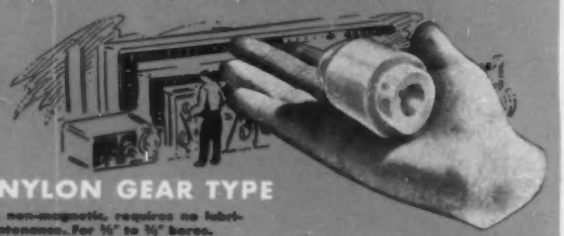
COUPLINGS

Their advanced design and exclusive construction features make them first choice of leading equipment builders. Your best insurance against costly shut-downs.



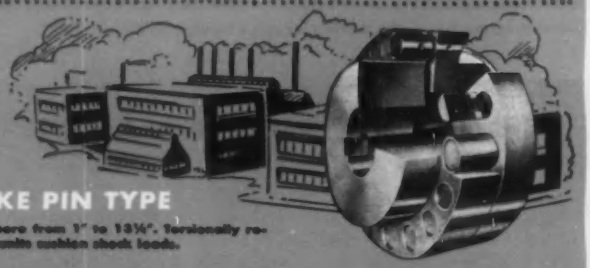
SERIES "A" GEAR TYPE

One-piece cover sleeve, crowned gear teeth, automatic lubrication, less rotating weight.



JUNIOR NYLON GEAR TYPE

Non-corrosive, non-magnetic, requires no lubrication. No maintenance. For ⅛" to ¾" bores.



FRANCKE PIN TYPE

Maximum bore from 1" to 13¼". Torsionally resilient. Pin units cushion shock loads.

WALDRON couplings are available in sizes up to 18" shaft diameter. We specialize in furnishing couplings for unusual applications and services. We would be pleased to send you our latest bulletin 55P upon request.

JOHN WALDRON CORPORATION

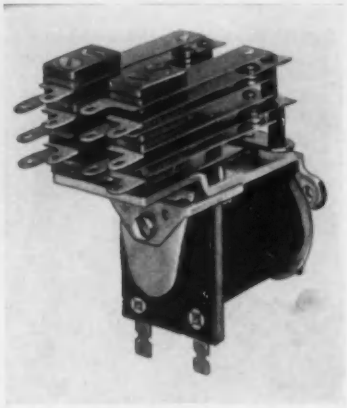
New Brunswick, N. J.

Since 1827

Sales Representatives In Principal Cities

to 3,000 psi; the particular range may be covered by one of four classes. The fixed actuation value varies from 10 to 250 psi. Barksdale Valves, 5125 Alcoa Ave., Los Angeles 58, Calif.

For more information—
Circle 65, inside back cover



All-Purpose Relays

Contact rating of this relay is 5 amp at 115 v, ac or 32 v, dc, non-inductive load. It is available from stock in a wide range of operating voltages, for ac or dc. Ohmite Mfg. Co., 3683 Howard St., Skokie, Ill.

For more information—
Circle 66, inside back cover

Spline-Locking Arbor

Turning an eccentric rod forces this arbor's cam action to rotate the locking ring section, clamping the work piece on each spline tooth. This clamping action centers the work piece, concentric to the pitch diameter of the spline.

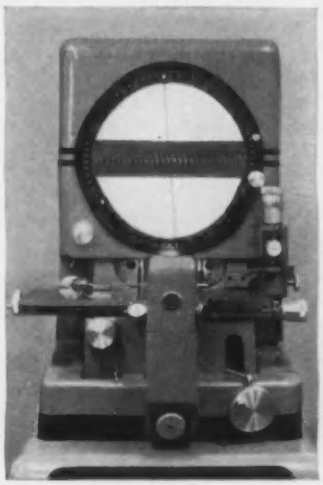
When the rod is returned to its

(Continued on page 270)

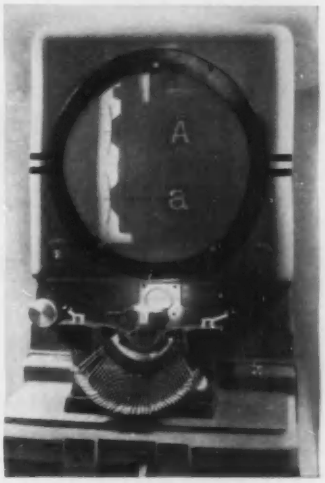
How many places in your plant can projection gaging save time and money?

In the toolroom? Look at this. Prior to adopting projection gaging, a Midwestern manufacturing plant required 725 man-hours monthly to inspect flat drills, taps, special cutters, and circular form tools. Use of a Kodak Contour Projector reduced inspection time 84% to 115 man-hours; cost of the projector was returned in direct labor savings within three months. If you have a heavy inspection load in your toolroom, chances are that optical gaging with Kodak Contour Projectors could effect similar savings for you.

In receiving? Here's the experience of a leading maker of aircraft engines. Their gaging procedure on jet engine blades called for inspecting 11 dimensions (including radii and angles) on the dovetail contour, 14 additional dimensions on the blade root. Using two Kodak Contour Projectors, they checked these pieces at a rate of 150 per hour. And operators required little training. What about your receiving inspection department? Couldn't a fast, highly accurate method of inspecting all sorts of parts with multiple dimensions and complex shapes help prevent bottlenecks?



In production? A lot of people don't think of optical gaging in terms of production inspection. A typewriter maker did. To check the alignment of type bars to ±.0002", they placed a Kodak Contour Projector next to the soldering jigs on which bars are mounted on their arms. Catching errors at this point and correcting the jigs reduced alignment time in final assembly 25%. Install Kodak Contour Projectors next to production equipment and you have a fast, continuing check that insures machine settings are correct. That's a good way to keep scrap costs down and quality up.



In final inspection? Ever have a part that was almost impossible to inspect accurately and completely? A leading West Coast electronics manufacturer did. They had to check the precise pitch of a fine wire helix mounted in its glass tube. "Without the Kodak Contour Projector," the company reported, "it would not be practical to make the measurements necessary to get a satisfactory instrument." Many times optical gaging on a Kodak Contour Projector lets you measure small or easily distorted parts with a simplicity and accuracy you can't achieve by other methods.

WHATEVER your inspection or measuring problem, there's a Kodak Contour Projector to do the work, from the bench-type Model 8 to the big Model 30 with its 30-inch screen and large part capacity.

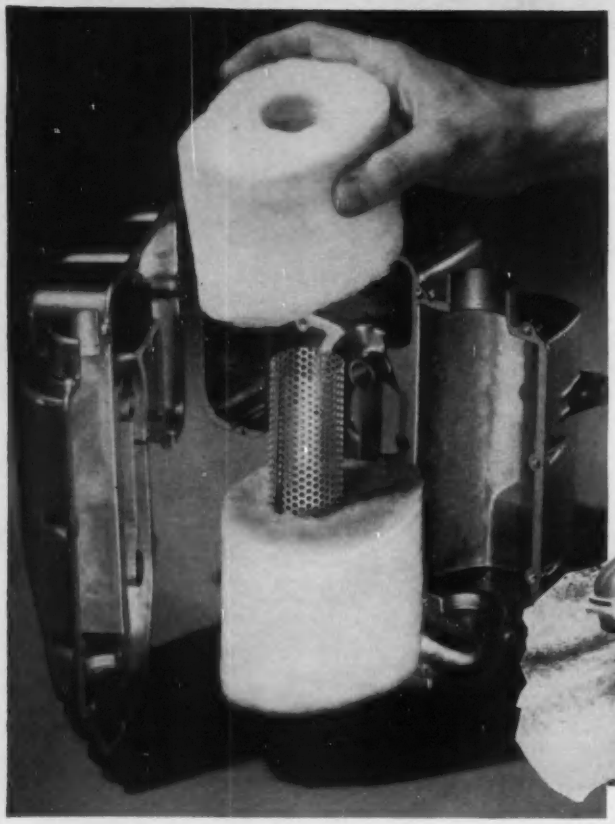
To find out more about how optical gaging can save you time and money, improve accuracy, send for the booklet, "Projection Gaging with Kodak Contour Projectors." Write *Special Products Sales Division.*

EASTMAN KODAK COMPANY, Rochester 4, N. Y.

the KODAK CONTOUR PROJECTOR

Kodak
TRADE-MARK

INSULATION news from L·O·F GLASS FIBERS COMPANY



S-h-h-h!

In Evinrude's Big Twin Aquasonic outboard motors, L·O·F Glass Fibers' insulation forms the carburetor intake silencers that help hold objectionable engine noise to a minimum.

Evinrude makes outboard motors "whisper" with L·O·F Glass Fibers' insulation

Got a noise problem? Like Evinrude's engineers, you may find the perfect answer in L·O·F Glass Fibers' Microlite or Super·Fine insulation!

Evinrude chose Microlite insulation for three reasons:

1. It has high acoustical efficiency—with millions of tiny dead-air cells trapped in its longer, finer glass fibers.
2. It resists air erosion even at high intake velocities.
3. It is easily die-cut to fit irregularly shaped housings.

Whether your insulating problem is acoustical or thermal, Super·Fine and Microlite offer efficient solutions *plus* all these design advantages . . .

- light weight
- low density
- high resiliency
- heat resistance
- low space requirement
- easy handling
- easy fabrication
- resistance to moisture and settling

For more information on design possibilities of L·O·F Glass Fibers' insulation, contact our nearest office; or write: *L·O·F Glass Fibers Company, Dept. 4–26, 1810 Madison Ave., Toledo 1, Ohio.*

LOF GLASS FIBERS
SUPER·FINE INSULATION

L·O·F GLASS FIBERS COMPANY

TOLEDO 1, OHIO

Makers of glass fibers by the exclusive "Electronic-Extrusion" process

Users of tubing for cylinder applications— now you can have this new...

J&L Cold Drawn ELECTRICWELD

Tubing with a Special Smooth ID Finish

Reduces your overall production costs in applications like these . . .

- **cylinder tubing**
- **hydraulic and pressure tubing**
- **shock absorbers**
- **ordnance components**

This new drawn-over-mandrel grade tubing with its mirror-like inside surface finish is today busy helping manufacturers reduce or entirely eliminate costly machining on many applications and is being substituted for more costly types of steel tubing. For example, it may be used, without inside honing, for many cylinders through which plungers are passed.

J&L Cold Drawn ELECTRICWELD Tubing with a *Special Smooth* ID finish combines the physical advantages imparted by today's modern electric welding techniques with those of cold working. It withstands high internal hydrostatic pressures, carries heavy torsion loads, resists high-frequency vibration, and offers a favorable weight-to-strength ratio for applications in which loading occurs in all directions.

J&L Cold Drawn ELECTRICWELD Tubing can be furnished in its three specifications in OD sizes from ¾-inch to 2¼ inches and in wall thickness from 20 to 10 gage, 0.035 and 0.134-inch respectively.

This new booklet provides the information you need . . . specifications . . . tolerances . . . chemistry . . . mechanical properties . . . annealing . . . finishes.

Send for your free copy today!

J&L STEEL

Jones & Laughlin Steel Corporation
Dept. 409, 3 Gateway Center, Pittsburgh 30, Pa.

Send me a copy of your new Cold Drawn ELECTRICWELD Booklet.

Name_____

Title_____

Company_____

City_____ Zone____ State_____

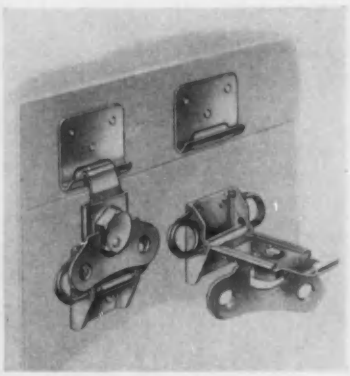
original position, the cam returns the locking ring back into alignment with the two fixed splines, releasing the piece being held. This arbor was designed to hold worm gears for turning and hobbying operations. Master Spline Tool & Gage Co., 19760 W. Eight Mile Road, Detroit 19, Mich.

For more information—
Circle 67, inside back cover

Spherical Union Connections for Valves

This connection for valves compensates for up to 10 deg misalignment in any direction from perpendicular axis and a wide variation in centers. When used with a side-connected gage, the spherical union on the tank connection side of the valve alone will permit a variation of plus $\frac{3}{8}$ in. to minus $\frac{3}{8}$ in. per valve, or a total of $\frac{3}{4}$ in. increase or decrease on centers. Jerguson Gage and Valve Co., 80 Fellsway, Somerville 45, Mass.

For more information—
Circle 68, inside back cover



Spring-Loaded Panel Lock

The spring action provides take-up to compensate for permanent set in gasketing, irregularities of sealing surfaces and mounting inaccuracies. Spring action is only effective up to 75 per cent of the fastener's maximum loading. When heavily loaded, the loads are carried by rigid members. This is said to eliminate the possibility of spring failure under maximum loading.

A 180-deg turn opens or closes lock.

(Continued on page 274)

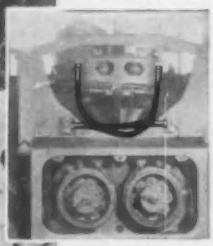
JOT NAME, TITLE AND ADDRESS IN THIS SPACE
TO START YOUR FREE "NELWELDER" SUBSCRIPTION

another way of saying.. **STUD WELDING IMPROVES EXTERIOR DESIGN**

Product designers and architects can smooth out the contours of many a rough exterior by employing the NELWELD® method of fastening. Numerous innovations in stud fastening which eliminate unsightly projections such as bolt heads, and costly bosses and flanges, are published monthly in the NELWELDER. Get in the swim—mail the top of this advertisement to receive your first free issue of the NELWELDER.

NELSON STUD WELDING
Division of Gregory Industries, Inc.
LORAIN, OHIO

PIONEERS IN POWER STEERING
...TURN TO Eastman
PIONEERS IN THE FIELD OF HYDRAULIC HOSE ASSEMBLIES

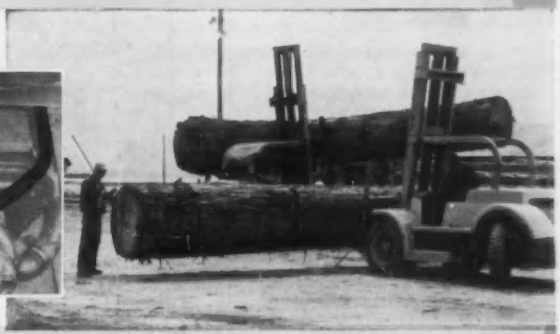


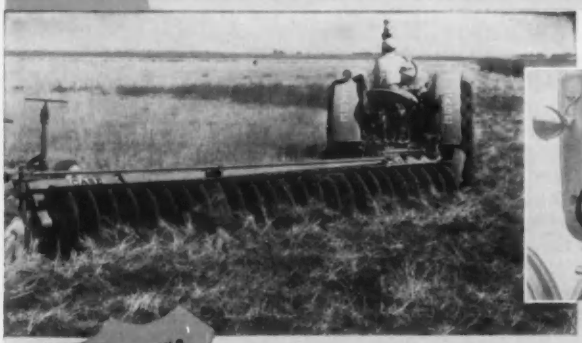
MOVING MOUNTAINS

Designers of this great mountain mover were pioneers in the application of hydraulic power in steering this type of earth moving equipment. Thus, *pioneers in power steering turned to pioneers in Hydraulic Hose Assemblies.* Hydraulic power—applied through Eastman Hydraulic Hose Assemblies to the twin brakes, shown here, wheel this International Model 75 "PAYSCRAPER" over rugged mountain terrain.

MOVING FORESTS

Eastman Hydraulic Hose, operating at 2000 lbs. p.s.i., delivers the power required to steer the rear axle, weighing 11,800 lbs., on this New "Hyster" SC-180 model. Due to heavy, load-balancing counter-weight over this axle, it would be impossible to steer this "King of the Lift Trucks" without hydraulic power when empty. Maximum maneuverability is attained through power steering—moving loads up to 9 tons, like these giants of the forest.





MOVING FIELDS

First tractor to use power steering—the Case "500" Diesel, at work here, uses Eastman "first in the field" Hydraulic Hose Assemblies for 1800 lbs. p.s.i. working pressure. Despite front end weight of 2470 lbs., hydraulic power makes steering almost effortless. Turning over 30 furrows in one "swath," this Case Disc Plow makes fields "move over" 18 feet at a time! Again, J. I. Case, *pioneers in farm machinery* since 1847, chose Eastman, *pioneers in Hydraulic Hose Assemblies.*

SAFEGUARDING INDUSTRY'S *Lifelines of Mobile Power*

Eastman
first in the field
MANUFACTURING COMPANY
Dept. PE-2, Manitowoc, Wis.

NOTE:
If you wish to be first in your field—come to Eastman—"first in the field" of Hydraulic Hose Assemblies.

WRITE for Catalog 101 on Eastman Hydraulic Hose Assemblies

RB&W FASTENER BRIEFS

RUSSELL, BURDSALL & WARD BOLT AND NUT COMPANY

Technical-ities

By John S. Davey

The important facts about nuts

A nut's purpose is to load the bolt in tension for a tight joint. For this, it is given shear strength greater than the breaking point of the bolt; and sufficient bearing area to avoid crushing or flow of the bearing surface with consequent reduction of tension.

While the thread form of a nut is accurate, its "lead" cannot, for practical purposes, be made identical with that of the bolt. Thus, a nut is made from material plastic enough to allow the threads to deform upon tightening and thereby adjust to distribute the load over many threads rather than concentrate it on the first few.

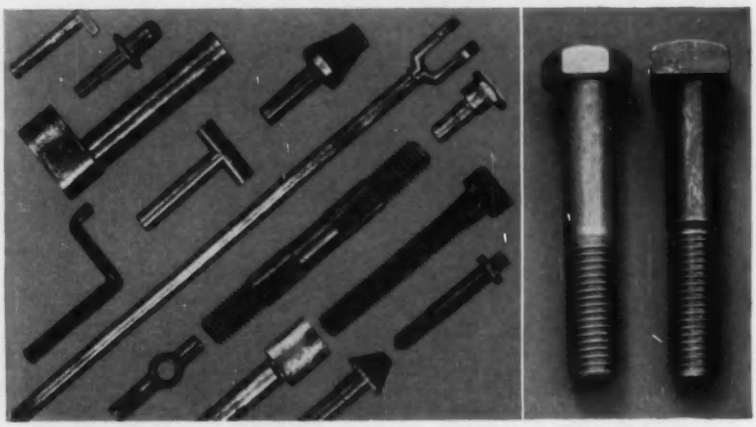
WHAT TO USE

The standard "Finished" nut series satisfies the requirements. It gives not only the required bearing area, but also enough section for proper strength and to minimize the spreading or dilation of a nut when loaded. (The standard "Heavy" nut series is called for only when bolt holes have large clearances, or for high bolt loads.)

As a good general guide to follow, use nuts that are:

1. Made to Am. Std. dimensions;
2. Made from soft, ductile material;
3. Strong enough to break the bolt or screw with which it is used. This would determine whether "Finished" or "Heavy" series is selected.

Cold heading produces strong, low cost parts



Representative range of mechanical parts produced by RB&W by cold heading . . . the same process used to produce the high quality, economical RB&W standard bolts and cap screws shown at right.

Here's a product-improving fact often overlooked: The same forming operation that produces large volumes of strong fasteners at surprisingly low cost can also be used for headed, special mechanical parts.

Cold heading upsets metal along its own axis. Flow lines are continuous, without folds, giving greater head strength against shear, fatigue and impact. Moreover, the material has better quality to start with, since unsound metal would distort or open in the operation and be rejected automatically. Uniformity is assured. Finish is also better.

Designers and production men get all these physical advantages when using RB&W standard bolts and cap screws. They can also have them in special parts at low cost when the need is of sufficient volume to justify machine set-up time. For more information and help on your specific needs, write Russell, Burdsall & Ward Bolt and Nut Company, Port Chester, N.Y.

Plants at: Port Chester, N.Y.; Coraopolis, Pa.; Rock Falls, Ill.; Los Angeles, Calif. Additional offices at: Ardmore (Phila.), Pa.; Pittsburgh; Detroit; Chicago; Dallas; San Francisco.

30% faster assembly — and joints stay tight

When famous-make chain saws were fastened with regular screws plus washers, they loosened on the job. Then SPIN-LOCK screws were used. These not only held tight, they also speeded assembly time 30%. What's more, they cost no more than former screw plus lock washer.

SPIN-LOCK screws have self-anchors in the form of hardened, tiny teeth which dig in and hold under severe service. Various types, sizes and heads available. Send for data or see Sweet's Product Design File.

MODEL R-30 SIZE. This motor is recommended for applications such as recording instruments, timers, office equipment and professional recording apparatus. Induction motor rating: 1/50 to 1/100 hp. Synchronous motor rating: 1/100 to 1/200 hp. Available with ball or sleeve bearings. Unique construction features provide 30% efficiency.

HOLTZER-CABOT

Fractional and Sub-fractional Motors Meet a Variety of Industrial Requirements

MODEL R-24 SIZE. *Typical uses: as a balancing motor in recording instruments, as a control motor for voltage regulators and in servo mechanisms.* This reversible, 4-pole induction motor has low rotor inertia. When operated 2 phase, it can be controlled electronically; it can also be operated single phase as a permanent split capacitor motor.

MODEL R-25 SIZE. *For recording instruments, dictating and adding machines.* Approximately 2½" in diameter, it is available in either induction or synchronous construction with reversible rotation. Both the R-24 and R-25 are available with speeds from ½ to 3600 R.P.M., torque ratings up to 75 oz. inches or higher, and single phase, 2 or 3 phase.

If it runs by electricity... rotates... and is not more than 7" in diameter—Holtzer-Cabot can make it!

P E

HOLTZER-CABOT MOTOR DIVISION
NATIONAL PNEUMATIC CO., INC.
125 Amory Street, Boston 19, Mass.

Gentlemen: Please send me data sheets on the Holtzer-Cabot R-30 ☐, and the R-24 and R-25 ☐.
Please have representative call on_____ (date)

*Name*_____

*Company*_____

*Street*_____

*City*_____ *Zone*____ *State*_____

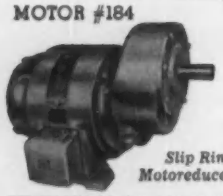
SAVE

on original development costs
by using REULAND ELECTRIC'S

SPECIAL-MOTOR "LIBRARY"

Over 900 Different
Electric Motors

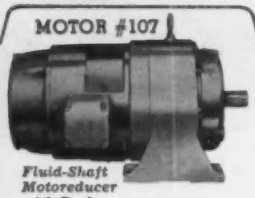
MOTOR #184



Slip Ring Motoreducer

HIGH STARTING TORQUE ON LOW CURRENT—plus variable speed reduction, are features of this Slip Ring Gear Reducer motor. Aids in getting heavy loads up to full speed through step by step starting.

MOTOR #107



Fluid-Shaft Motoreducer with Brake

FLUID-CUSHIONED ACCELERATION, SLOW SPEED, SPLIT-SECOND BRAKING—Internal fluid coupling provides smooth starts, prevents "jamming" of equipment. New "doughnut" magnetic brake can be mounted before or after coupling—or both.

MOTOR #841

Hydraulic Pump Mount Motor

MOUNT PUMP DIRECTLY TO MOTOR'S END BELL—Eliminates usual need for separate pump-mount platform. Insures absolutely perfect alignment with pump shaft. Available with flange on one or both ends. For all standard pump makes.

MOTOR #912

Right-Angle Worm Motoreducer

COMPACT SPEED REDUCER—This right-angle, worm type gear reducer provides lowest cost speed reduction. Mounts on floor, overhead or side. Extremely versatile, multi-shaft load hook-up. Fits tightest quarters.

REULAND'S "XPANDABLE" DESIGN MEANS ALMOST UNLIMITED ADAPTABILITY...

Don't pay for special motor development until you first check the Reuland SPECIAL-MOTOR LIBRARY. Reuland's revolutionary new XPANDABLE DESIGN idea has produced literally hundreds of unique power packages, one of which may already be the answer to your needs.

Reuland also produces a complete line of standard electric motors. Free engineering literature will be sent upon request. Your inquiry will be given prompt, personal attention.

REULAND ELECTRIC COMPANY
Distributors In All Principal Cities

Western Division: Alhambra 20, Calif. — Eastern Division: Howell 20, Mich.

Model No. 2 will safely carry up to 1000 lb tension loading, while No. 3 will carry up to 300 lb tension. Simmons Fastener Corp., 1700 N. Broadway, Albany 1, N. Y.

For more information—
Circle 69, inside back cover

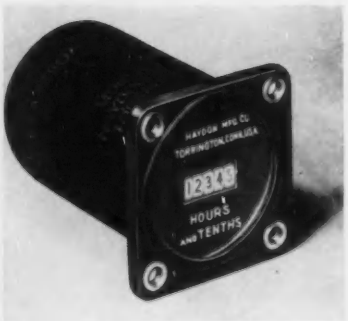
Die-Drawn Flat Wire

Flat wire for fine spiral springs is now drawn flat through diamond dies to a tolerance of ±5 micro-in. Torque variations in springs made of this uniform wire are said to be even less than variation errors found in available torque-measuring apparatus.

Flat drawing is said to give a longitudinal grain, improve cold working, make a harder, tougher and strong ribbon wire. Diamond dies give an excellent polished finish to the wire which improves fatigue and corrosion resistance.

Ribbon or rectangular wire can be drawn in any size from 0.003 by 0.0003 in. to 0.060 by 0.025 in. Any combination of these dimensions may be drawn flat, of any metals which are ordinarily drawn by conventional round-die methods. Instrument Wire Co., 41 Kendall Ave., Maplewood, N. J.

For more information—
Circle 70, inside back cover



Elapsed Time Indicator

This running time meter is a direct-reading counter, with a synchronous motor drive, in a 1½ in. dia dusttight case. The unit is 2¾ in. in length, weighs approximately 6¼ oz and uses 2 w of power. Two models are available, one indicating hours in ⅒ hr steps to 9999.9; the other, minutes

(Continued on page 278)

AlSiMag®
advanced ALUMINA CERAMICS

with new HIGH

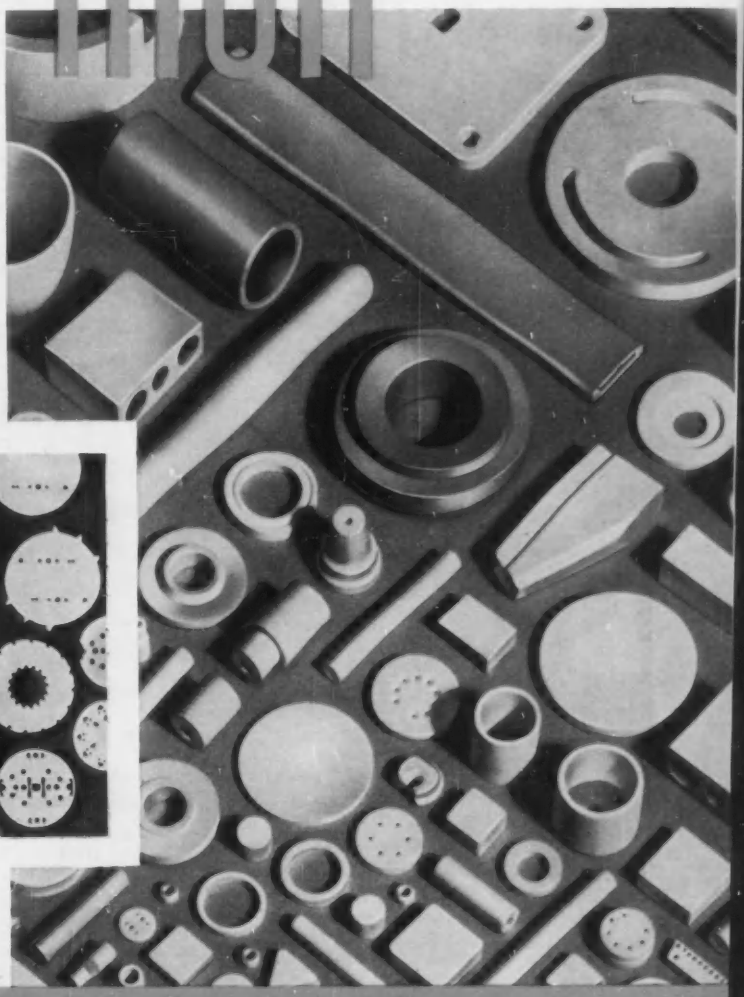
temperature

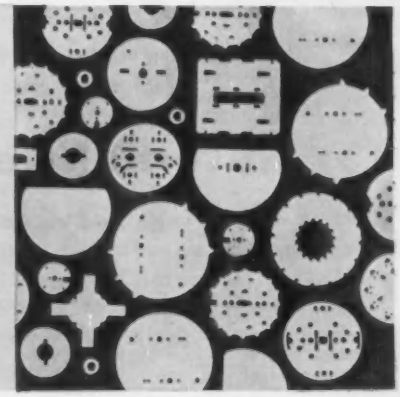
strength

quality

production

Greatly enlarged facilities now produce high quality, pace-setting AlSiMag Alumina ceramics in quantity lots. Complete range of up-to-the-minute Alumina compositions now permit you to design to higher temperatures and higher strengths. Advantages include improved electrical characteristics at elevated temperatures—beyond the melting point of most metals. Higher tensile and impact strengths. Greater resistance to corrosion and abrasion. Smoothness of texture. Close dimensional tolerances. Custom formulations for special needs.





Volume production in a complete range of precision parts, including electron tube shapes processed to be highly porous, readily degassed, thicknesses as low as .009".

• An outline of your requirements, enclosing a blueprint or sketch, will bring you full details.

54TH YEAR OF CERAMIC LEADERSHIP

AMERICAN LAVA CORPORATION

CHATTANOOGA 5, TENNESSEE
A Subsidiary of
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Branch offices in these cities (see your local telephone directory): Cambridge, Mass. • Chicago, Ill. • Cleveland, Ohio • Dallas-Houston, Texas • Indianapolis, Ind. • Los Angeles, Calif. • Newark, N. J. • Philadelphia, Pa. • St. Louis, Mo. • South San Francisco, Calif. • Syracuse, N. Y. • Tulsa, Okla. **Canada:** Irvington Varnish & Insulator Div., Minnesota Mining & Mfg. of Canada, Ltd., P. O. Box 757, London, Ontario. **All other export:** Minnesota Mining & Mfg. Co., International Division, 99 Park Ave., New York, N. Y.

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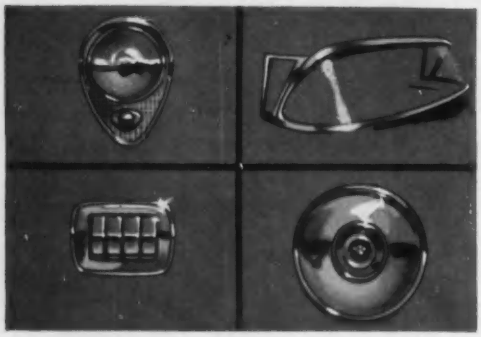


The beautiful bright molding and trim that style your car are made of non-corrosive, easy to clean Stainless Steel. Designers of automobiles and hundreds of other products specify Stainless Steel for its many valuable properties.

For the product you make today and the product you plan for tomorrow specify McLouth high quality sheet and strip Stainless Steel.

McLouth Steel Corporation
Detroit, Michigan

MANUFACTURERS OF STAINLESS AND CARBON STEELS

SEALING ELECTRICAL CONNECTORS AGAINST MOISTURE AND VIBRATION... BY FLOWING "THIOKOL" SYNTHETIC RUBBER INTO VOIDS

Improved seals for electrical connectors and other electrical equipment are obtained by utilizing "Thiokol" liquid polymer as the base material in electrical potting compounds. "Thiokol" liquid polymer is a solventless *liquid* synthetic rubber that converts to a resilient *solid* rubber at room temperature without shrinkage.

Potting compounds based on this polymer come in the form of a paste that can be pressure flowed into voids around wiring. They set at room temperature and completely fill all voids with a resilient rubber that adheres tenaciously to metals, glass and most plastics.

Electrical connectors containing these potting compounds are positively sealed against moisture, solvents and contamination under conditions of severe vibration and temperature extremes. Significant reductions in space and weight of the electrical connectors are accomplished, and wire fatigue is avoided.

Potting compounds based on "Thiokol" liquid polymer are widely used in connectors for aircraft, guided missiles and other electrical equipment. They have helped establish new standards in reliability and design. They may do the same for your equipment.

Sealing electrical connectors by pressure-flowing PR-1201-Q*, an electrical potting compound based on "Thiokol" Liquid Polymer.

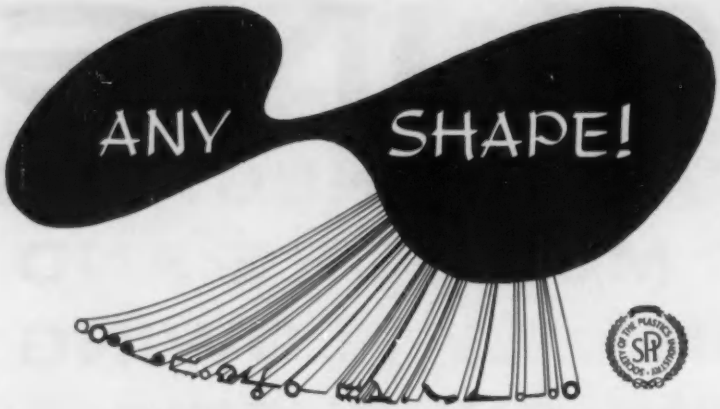
Write:
THIOKOL CHEMICAL CORPORATION,
784 N. Clinton Ave., Trenton 7, New Jersey.

IN CANADA: Naugatuck Chemicals Division, Dominion Rubber Company, Elmira, Ontario.

***Thiokol Chemical Corporation supplies "Thiokol" Liquid Polymer only as a raw material. PR-1201-Q, the "Thiokol"-based compound illustrated, is made by Products Research Corporation, 3126 Los Feliz Boulevard, Los Angeles 39, Calif.**

Thiokol®

PIONEER MANUFACTURERS OF SYNTHETIC RUBBER



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Mr. Design Engineer:
We offer you the Relay that eliminates controlled timing problems

PRE-SET TAMPER PROOF TIMER-RELAY

This steel clad, factory set, tamper proof Durakool timer-relay is practically non-breakable. Operating life multiplied 5 to 6 times by new plunger construction features. Any combination of operate-release-time delays from 0.15 sec. to 20 sec.—either normally open or normally closed action.

Send for Bulletin 800

See telephone directory for local distributor, or write.

GUARANTEED FOR AC-DC APPLICATION and:

- ★ No false contacts
- ★ Non sticking
- ★ Practically "fail safe"
- ★ Low cost timer

DURAKOOL, INC.
ELKHART, INDIANA, U.S.A. ••• 700 WESTON RD., TORONTO, CANADA

Durakool ALL-STEEL MERCURY Timers

in $\frac{1}{10}$ min graduations to 9999.9 (166.6 hr). The unit operates on 115-v, 60-cps current, and can be mounted either behind or in front of the mounting panel. Haydon Mfg. Co., Inc., 245 E. Elm St., Torrington, Conn.

For more information—
Circle 71, inside back cover

Multiple Thread Stake Nut

The lower leg of this fastener is designed with a formed catch that holds the nut in position on the panel hole for ease of assembly. It acts as a lock washer when the assembly is in secure position. The panel hole size determines the amount of float desired in the stake nut. These nuts are available in various multiple thread nut sizes and panel ranges. Prestole Corp., 1345 Miami St., Toledo 5, Ohio.

For more information—
Circle 72, inside back cover

Pushbutton Actuators For Switches

A plastic push-button and a smooth, clear anodized bushing are exposed above the mounting surface. Buttons of both $\frac{1}{2}$ and 1 in. dia are available in a choice of red, green or black. Many different types of basic switches can be used with the actuators, in-

(Continued on page 279)

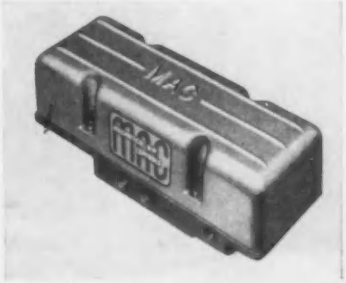
cluding hermetically sealed switches, high capacity switches, double-pole, double-throw switches and magnetic blow-out switches. The actuator can be mounted through panels of $\frac{1}{16}$ to $\frac{1}{8}$ in. thickness. Micro Switch, Freeport, Ill.

For more information—
Circle 73, inside back cover

Germanium Power Rectifier

Occupying a volume of 190 cu in., this 30 kw liquid cooled rectifier may be connected as a three-phase, half-wave unit, for a six-phase star operation, three-phase center tap, or as a dual three-phase half-wave unit to be used with interphase transformers. Depending on the circuit, output currents of 540 to 750 milliamp can be obtained. The assemblies can be supplied for input voltages of 26 to 66 v rms, max. International Rectifier Corp., El Segundo, Calif.

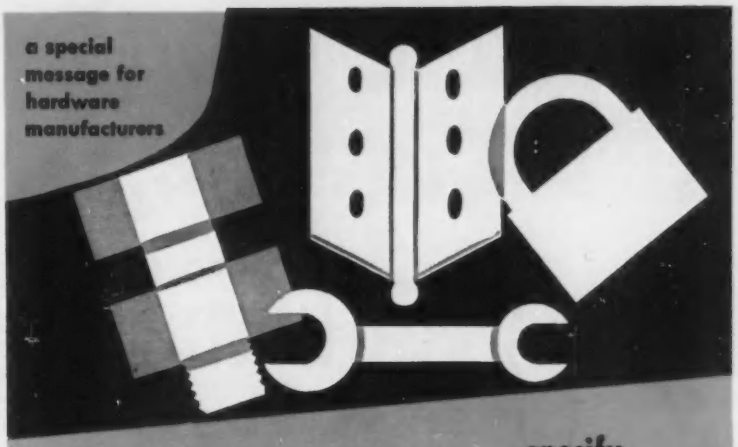
For more information—
Circle 74, inside back cover



Double Solenoid Air Valve

A three-position, four-way solenoid valve also has a neutral position and is available with either open or closed centers. On the open center model, both cylinder ports are open to exhaust and pressure is blocked when solenoids are de-energized—leaving the

(Continued on page 280)



need a finish for protection—decoration—identification? specify IRIDITE®

Specify Iridite . . . for corrosion protection during storage or use . . . for a firm and lasting base for paint . . . for extra quality and eye-appeal . . . for low cost color coding of finished parts.

ON ZINC AND CADMIUM you can get highly corrosion resistant finishes to meet any military or civilian specifications and ranging in appearance from olive drab through sparkling bright and dyed colors.

ON COPPER . . . Iridite brightens copper, keeps it tarnish-free; also lets you drastically cut the cost of copper-chrome plating by reducing the need for buffing.

ON ALUMINUM Iridite gives you a choice of natural aluminum, a golden yellow or dye colored finishes. No special racks. No high temperatures. No long immersion. Process in bulk.

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AND IRIDITE IS EASY TO APPLY. Goes on at room temperature by dip, brush or spray. No electrolysis. No special equipment. No exhausts. No specially trained operators. Single dip for basic coatings. Double dip for dye colors. The protective Iridite coating is not a superimposed film, cannot flake, chip or peel.

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WEST COAST LICENSEE: L. H. Butcher Co.

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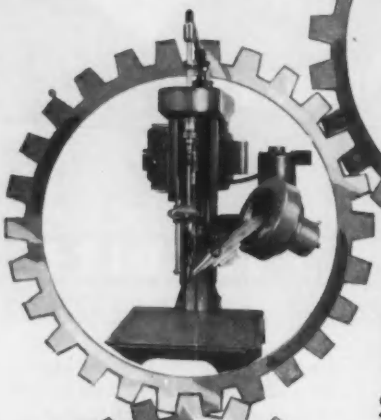
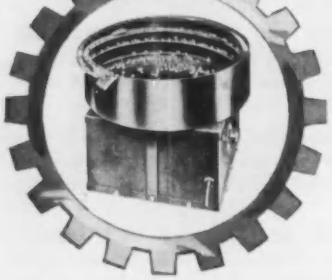
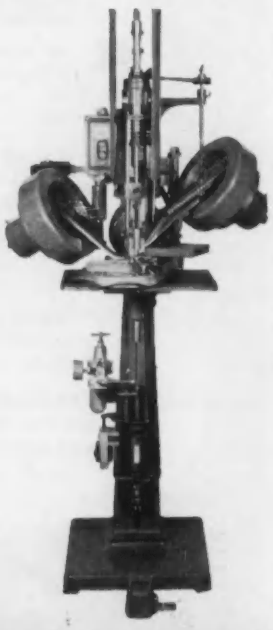
MAXIMUM OUTPUT — MINIMUM COSTS





DPS POWER SCREWDRIVERS and SELECTIVE FEEDERS *enable you to meet requirements in today's competitive market.*



● Line up this modern "gear train" for added profits. The DPS Power Equipment line is complete and flexible . . . Adaptable to the majority of production bottlenecks . . . It could be the answer to your problem . . . Tell us your story . . . Send for detailed catalog . . . Write today.

DETROIT POWER SCREWDRIVER CO.

2821-A W. FORT ST. DETROIT 16, MICHIGAN

cylinder rod in a free state. When energized, one port opens to line pressure, the other remains open to exhaust.

The ports of the closed center model are blocked from pressure and exhaust when solenoids are de-energized, holding the rod in a locked position. When energized, one port opens to pressure, the other to exhaust. Both models are currently available in ¾ in. IPS. Mechanical Air Controls, Inc., 10030 Capital, Oak Park, Detroit 37, Mich.

For more information— Circle 75, inside back cover

Dial Thermometer

A bimetallic thermometer for such industrial and institutional services as pipe lines, hot water tanks, storage tanks, ovens, air ducts, bottle washers, food cookers, sterilizers. Accurate within ±1 per cent of range over the entire range, it is available with 3 or 5 in. dials and stem lengths of 4, 6, 9 and 12 in. Separable wells of brass, steel, Type 304 stainless steel or Monel are available. Ranges of the various instruments run from −40 F to 750 F. All exposed metal parts are of arc-welded corrosion-resistant stainless steel. Taylor Instrument Co., 95 Ames St., Rochester 1, N. Y.

For more information— Circle 76, inside back cover

Template for Dot-and-Dash Lines

Produced for making piping drawings, the template is applicable to architectural or mechanical drawing, where various broken-line combinations are desired. The template will produce six different lines. It is made of transparent plastic, 0.0075 in. thick.

(Continued on page 283)

60 second tour

shows it in a nutshell . . .

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COMPRESSION SPRINGS
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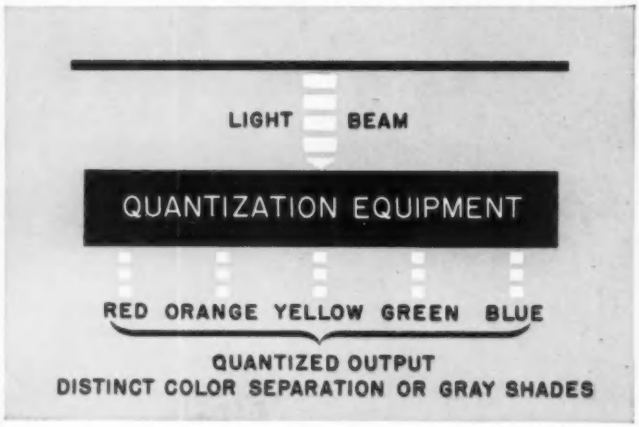
FORD INSTRUMENT QUANTIZES LIGHT

Colored lines or spots on a piece of paper can become a means of conveying information – Rorschach charts, impressionist paintings and survey maps are all visual message carriers. Ford Instrument engineers found it necessary to translate such color information into electrical or mechanical quantities, (quantization) with less distortion than is inherent in the usual photographic techniques. Such quantities can in turn be used as signals that actuate computers, make offset plates, and generally put to use the information implied by the difference between the colors or the distribution of the colors.



The quantization performed by Ford is not restricted to color alone. For example, a black and white photograph represents an aggregate of light and dark areas of varying shades, and this display must frequently be converted into continuous or discrete electrical quantities for various purposes and uses. Ford engineers recently developed equipment which can quantize and record the various degrees of color, or gray areas in photographic negatives, and to correlate this information into usable data. This equipment was developed for a classified project – the equipment is unavailable for general use – however the technical know-how gained by Ford – combined with Ford's superior production and engineering facilities – is available in the creation of light quantizing equipment for you.

Light quantizing is but one of the many facets of Ford Instrument design and development. For more information about Ford's products, services and facilities, write for an illustrated folder. Ford engineers will be happy to discuss your problems of control with you.

88

FORD INSTRUMENT COMPANY
DIVISION OF SPERRY RAND CORPORATION
31-10 Thomson Avenue, Long Island City 1, New York
Beverly Hills, Cal. • Dayton, Ohio

Ford's capabilities are among the finest in the country

Three dimensional cams are used in elaborate computing devices to characterize shell ballistics, magnetic variation, or to solve some basic mathematical function. Precision in 3-D cams is of vital importance. Ford Instrument designed and built a unique machine that can produce extremely accurate cams from a skillfully made master. As many as two thousand data points are end-milled to set precisely the contours of the handcut masters.

Equipment used for defense must undergo rigorous tests for accuracy and dependability in combat. At Ford, environmental testing laboratories reproduce extremes of desert or arctic battle, shock of warship broadside, salt fogs and heavy seas. When flaws have been detected and corrected, equipment is okayed for volume production and use throughout the armed services.

Typical of Ford Instrument's 40 years of experience in precision control is its work in the field of nuclear power. The Company, for example, is building the control rod drive mechanism for the Seawolf, second atomic submarine. Reactor designs, sensing mechanisms, control equipment and systems, nuclear calculations, and other specialized equipment and abilities are offered by the Company to this expanding industry.

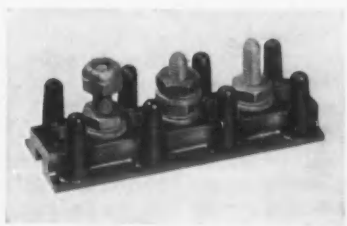
The template is used by placing a straight edge on the desired stencil and drawing the line. Dot-N-Dasher, Box 668, Cresskill, N. J.

For more information—
Circle 77, inside backcover

Thermal Time Delay Relay

Timing may be adjusted from the outside of this relay without affecting the hermetic seal. A standard hex key applied to a setscrew located in a recess at the top of the housing is the means of adjustment. Factory set relays are available in five overlapping timing ranges, from 5 to 99 sec. Standard units are mounted on nine-pin miniature plugs. They operate normally open or normally closed, single-pole, single-throw. They will carry 3 amp at 115 v, ac, or 28 v, dc, non-inductive. Housing is $\frac{11}{16}$ x $1\frac{3}{8}$ in. long. Total weight is under 1 oz. Belltron Mfg. Co., Inc., 204 Second St., Elizabeth, N. J.

For more information—
Circle 78, inside back cover

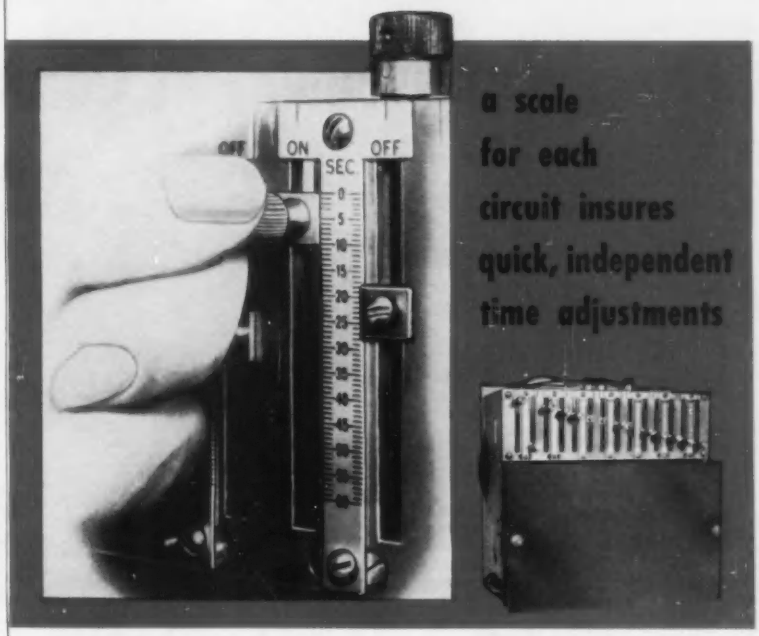


Terminal Strips

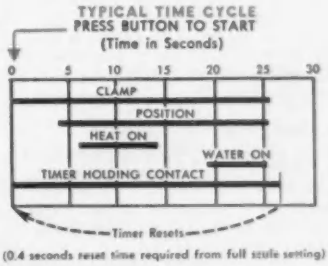
These terminal strips have post-type barriers and studs for attachment of single or multiple terminal ended or looped wires. They are available

(Continued on page 285)

EAGLE MULTIFLEX (multiple circuit) reset timer



For controlling operation phases of electrically energized devices in processing work. The Multiflex Reset Timer closes and opens one to six circuits during a time interval started by push button, limit switch or other means. It's the only multiple circuit timer that provides a calibrated scale for quick, independent adjustment of each circuit. Time changes are made rapidly by moving a simple slide adjustment. Settings are possible to 1% of full scale. Vernier knobs are provided for use where more accurate settings are required. Multiflex Timers are available with time scales from 30 seconds to 5 hours. Send for free bulletin.



(0.4 seconds reset time required from full scale setting)

MAIL COUPON TODAY

EAGLE SIGNAL CORPORATION
Industrial Timers Division
MOLINE, ILLINOIS

Eagle timers save time . . . save money

EAGLE SIGNAL CORPORATION
Industrial Timers Division, Dept. PE-256
MOLINE, ILLINOIS

Please send Bulletin 130 containing full data on Multiflex Reset Timer.

NAME AND TITLE

COMPANY

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News about
COATINGS for METALS
Metallic . . . . . Organic . . . . . Decorative . . . . . Protective

New improvement in Chromium Plate

Chemical-resistant coatings make durable product finishes

Finishes on a product today are exposed to a wider variety of chemical products than ever before. Service conditions are more severe. Chemical resistance in a finish has become of prime importance. Fortunately, designers have available coatings which can supply the proper chemical resistance.

Unichrome Plastisol Compounds combine the wide-range chemical inertness of vinyls with the pore-free, seamless and mechanical protection of a resilient, tough, thick film. They give also a satin-lustrous, rich finish.

PLASTISOLS NOW EASY TO APPLY

Unichrome Coating 5300 is *sprayable*, and builds a protective film up to 20 mils thick in one coat. For products of dippable size, Unichrome Series 4000 Plastisols are being used.

SYNTHETICS FOR SERVICE

With Unichrome Lacquers, Synthetics and Enamels, designers can specify the combination of properties needed to meet production as well as service requirements. Attractive yet durable finishing can be achieved on products exposed to heat, oils, chemical substances, outdoor exposure, moisture, caustics, acids and the like.

WHEN PROTECTION IS PRIMARY

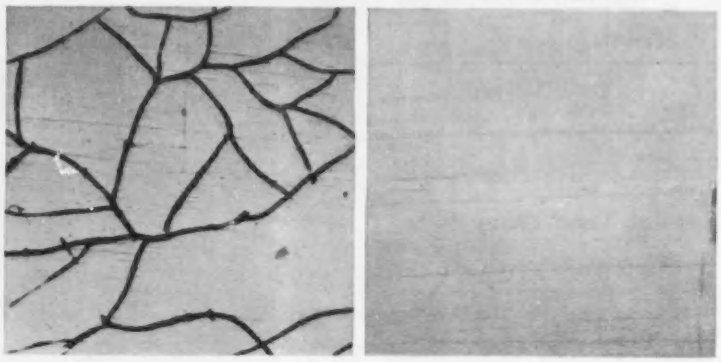
UCILON* Coating Systems were developed primarily for maintenance use, but are also used for product protection. The numerous coatings are of the vinyl, phenolic, fish oil, neoprene, Thiokol and chlorinated rubber types.

Send for Bulletins Chem-C-1 and PF-1 which give more data. *Trade Mark

UNITED CHROMIUM DIVISION
METAL & THERMIT CORPORATION

100 East 42nd Street, New York 17, N. Y.
Waterbury 20, Conn. • Detroit 20, Mich.
East Chicago, Ind. • Los Angeles, Calif.
In Canada: Metal & Thermit-United Chromium of Canada, Limited, Toronto 1, Ont.

Crack-Free Chromium Deposits give unique protection to parts



(Left) Surface view of etched ordinary chromium surface, enlarged about 75X, shows typical network of cracks. (Right) Etched Crack-Free Chromium surface shows none of this. Steel parts are therefore securely protected from rust.

Electrodeposits become continuous surfaces as thickness increases and porosity vanishes . . . except for *ordinary* chromium plate. Something else happens. Cracks develop as the chromium deposit builds up. Through these defects, corrosives reach the underlying metal. Unichrome Crack-Free Chromium eliminates these structural imperfections.

Comparative tests have demonstrated that Crack-Free Chromium makes a tremendous difference in corrosion protection.

At 110° F, and 100% relative humidity, only .0003" of Unichrome Crack-Free Chromium protected steel from rust for over 1000 hours. With ordinary chromium, identical parts were rust-covered in just *days*. In testing protection of .0005" of chromium plate in salt spray for 100 hours, one user found steel shafts protected with Crack-Free Chromium unaffected; while shafts with ordinary chromium were enveloped with rust.

WHERE TO USE

That is a question best answered by product designers. Knowledge of the complete advantages may suggest many uses. Crack-Free Chromium also offers:

1. Wear-resistance, hardness, and low friction.
2. Improved non-galling, non-seizing properties.
3. A more ductile deposit, resistance to thermal shock and better protection at elevated temperatures. Good impact resistance.
4. Excellent leveling action which helps cover surface imperfections. Also easier, faster grinding, if required.
5. Protecting the base metal without undercoats, Crack-Free Chromium can be used directly on steel or zinc base die castings for many applications.

APPEARANCE

A satin, matte finish, Crack-Free Chromium can be left as is, or readily buffed to high luster. Ask for recommendations, or send for Bulletin CFC-1.

with No. 6 studs in from one through twenty circuits, with No. 8 or No. 10 studs in from one through sixteen circuits, and with $\frac{1}{4}$, $\frac{5}{16}$ and $\frac{3}{8}$ in. studs in from one through eight circuits. Buchanan Electric Products Corp., Hillside, N. J.

For more information—
Circle 79, inside back cover

Multi-Purpose Power Supply

Designed to power all types of laboratory, field and factory electronic test setups, this power supply offers a voltage range of 0 to 500 v and no-load to full-load regulation of better than ±0.25 per cent, or 0.5 v. Ripple is less than 1 milliv. There are separate current and voltage meters, with push-button range switching for measurement of very small voltages and currents.

The instrument weighs 18 lb and is enclosed in an all-metal case with carrying strap. Hewlett-Packard Co., 395 Page Mill Road, Palo Alto, Calif.

For more information—
Circle 80, inside back cover

Coating Thickness Gage

This gage is said to be able to determine coating thickness on radii (irregular or curved surfaces present no problem). It will not damage coatings. There are two scales, one with standard calibration for non-magnetic coatings on a mild steel base, and, on the reverse side, a linear scale 0-10 units for special calibrations. Mean accuracy: ±15 per cent or 0.0001 in., whichever is greater. Range: 0.0002

(Continued on page 289)

Compact new Gast rotary No. 6 Air Motor delivers

TWO HORSEPOWER

. . . weighs only 17 pounds

Here's compact, light-weight power—offering many advantages as original equipment on your products! With the new 2 h.p. Model 6AM added to the line, Gast offers rotary air motors in five popular sizes from the 1/20 h.p. Model 1AM to the 4 h.p. Model 8AM.

To fulfill designers' needs, Gast also offers standard variations on some models, including foot or flange mountings for vertical or horizontal applications with direct or gear drive . . . special reversible rotation, etc. Well adapted for plant use or as original components, Gast Rotaries are *explosion-proof, variable in speed, burn-out proof* even when stalled—and low in first cost!

Wherever compressed air is available, they're a power source worth investigating! *Write for Model 6AM Bulletin 855*—or specify size that interests you. *Request "Application Ideas" Booklet too!* — **Gast Manufacturing Corp.**, P.O. Box 117-V, Benton Harbor, Michigan.

Original Equipment Manufacturers for Over 25 Years

GAST ROTARY

- **AIR MOTORS** TO 4 H.P.
- **COMPRESSORS** TO 30 P.S.I.
- **VACUUM PUMPS** TO 28 IN.

SEE OUR CATALOG IN SWEET'S PRODUCT DESIGN FILE

Just turn the key..

An R&M Motor

Just turn the key, and a Robbins & Myers custom-designed motor starts the powerful new Mercury 4-cylinder-in-line Mark 55E 40 HP outboard motor, and also the popular 18 HP Mercury Mark 25E model.

This outstanding electrical starter and generator system is the result of extensive research and design work by engineers of the Kiekhaefer Corporation, Fond du Lac, Wisconsin, makers of Mercury outboard motors. Rigid requirements were established on all parts to assure unfailing performance and long service under the conditions in which outboard motors must operate.

One of the most important single factors is the starting motor. It must operate on the 12-volt system, be compact, provide high torque. It must withstand the heavy starting load, rough handling, vibration, exposure to marine conditions. Kiekhaefer engineers handed the problem to Robbins & Myers motor design specialists.

These R & M engineers custom-designed the motor for the job. It develops 8/10 HP at 6000 RPM. It's compact, with an overall length of 6 inches and outside diameter of less than 3½ inches. Commutator, windings, and connections are specially designed for 12-volt service. The motor shaft is specially splined and hardened to resist sudden starting loads. The whole motor is marine-treated with special moisture-proofing to protect it against fresh and salt water, and tropicalized with fungicidal lacquer.

Kiekhaefer engineers, after extensive tests, report that the R & M motor amply meets all the requirements. It has now been used on the Mark 55E and Mark 25E for millions of enjoyable hours. Users are enthusiastic about the smooth, unfailing performance of the "Turn-the-Key" starting system.

Above, cutaway view of the Mercury Mark 25E outboard motor showing location of the R & M starter, and, right, R & M matched motor parts custom-designed especially for this application. Parts are marine-treated and tropicalized to resist salt water and fungus.

starts this new Mercury outboard

How R & M Engineers coordinate motors with your machine design

The Mercury electric motor starter is just one of thousands of applications that require a custom-designed motor. Robbins & Myers engineers specialize in integrating motors with your design problems in building a machine.

We custom-design matched motor parts for portable tools, industrial equipment, appliances, office machines, many other applications. R & M engineers have developed a special electric "slide rule" that cuts motor designing calculation time from months to days. The resultant cost and time savings are passed on to you.

It may be that an R & M standard motor will completely meet your requirements. If so, we can select from our wide choice of types and sizes of complete motors or matched motor parts.

But don't be satisfied with an "off-the-shelf" compromise. Bring your problems to R & M—we'll work with you—in complete confidence—and you can be sure of getting the motors or motor parts that best meet your requirements. Call the nearest Robbins & Myers office—or mail the coupon below for complete information about R & M service.

R&M® ROBBINS & MYERS, INC.

SPRINGFIELD, OHIO • BRANTFORD, ONTARIO

Fractional HP motors from 1/200 HP • Integral HP motors to 200 HP

R & M Motors and Motor Parts power many types of equipment

Portable power tools . . . vacuum cleaners . . . hedge trimmers and lawn mowers . . . police and air raid sirens . . . food mixers . . . pumps and compressors . . . electric typewriters . . . electronic calculators . . . fans . . . oil burners . . . waxers and polishers.

Mail This Coupon . . . No Obligation

PD

Robbins & Myers, Inc., Springfield, Ohio

Without obligation, please send me bulletins on:

- ☐ Motor parts for portable tools
- ☐ Universal motors
- ☐ Capacitor Motors
- ☐ R & M "All-Weather"* Motors up to 200 HP
- ☐ Please have a motor specialist call on me.

*"All-Weather" is an R & M trademark

*Name*_____

*Firm*_____

*Address*_____

*City*_____ *State*_____

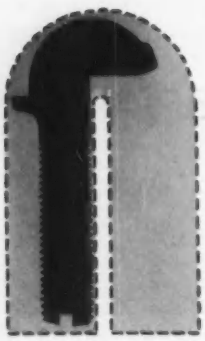
Eight operations cut to four

The old way:

The stud shown here was used by a tank manufacturer to blind feed into a tubing hole during assembly. Multiple diameters were required to hold the stud tight after insertion. To achieve this rather intricate shape, eight operations were originally required . . . until National was asked to study the problem.

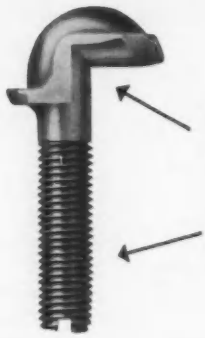
The National way:

Our "Special Products Service" showed this manufacturer how the stud could be produced to specifications *in only four operations* by cold-heading. Because National had the wide range of cold-heading equipment and specialized know-how needed to do the job, production costs were cut 50% . . . and substantial material savings resulted because cold-heading leaves a minimum of scrap.



OLD WAY

Bar stock bent in U-shape was machined to specifications in eight operations, with considerable waste of metal.



THE NATIONAL WAY

Head was upset into shape needed with multiple diameters.

Only four operations needed to complete stud by cold-heading and roll threading.

Bring your "Special" problems to National

Can we help you realize the same type of economy on *your* special fastener needs? Our "Special Products" representative will be glad to study your specifications. Write for free copy of National's "Special" fastener booklet.

Representatives in:
Chicago, Cincinnati, Detroit, New York, Philadelphia, Kansas City, Milwaukee, Rochester, Denver, St. Louis, San Francisco and Seattle.

THE NATIONAL SCREW & MFG. COMPANY
Cleveland 4, Ohio
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3423 South Garfield Ave., Los Angeles 22, Cal.

MANUFACTURERS OF PHILLIPS SCREWS

National PRODUCTS

Fasteners Hodell Chains Chester Hoists

to 0.015 in. (0-400 micron). Various applications may require separate calibrations.

To make a measurement, the exploring head or magnet is placed on the surface and the body of the gage is drawn away, thus extending the spring. The spring extension, the amount of which is observed on the scale, is proportional to the force required to detach the magnet from the surface. The reading is taken at the point where the magnet breaks away from the surface, and, from a calibration curve, the coating thickness is determined. James G. Biddle Co., 1316 Arch St., Philadelphia 7, Pa.

For more information—
Circle 81, inside back cover

Light-Weight Power Supply

This magnetic amplifier regulated power supply is rated at 2 to 36 v at 15 amp. It contains no moving parts. A-c input is 105 to 125 v single-phase, 60 cps. Voltage regulation is $\pm\frac{1}{2}$ per cent over the range of 5 to 32 v, ± 2 per cent from 2 to 5 v and 32 to 36 v.

(Continued on page 292)

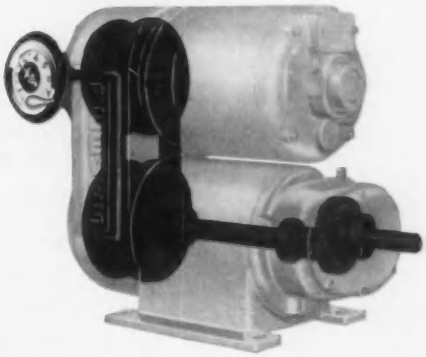
REEVES

the right speed for every need!

fractional HP Vari-Speed
MOTODRIVE

compact, attractive design

Within streamlined, metallic blue housing is REEVES' "weatherized" motor, time-tested speed changing mechanism, and heat-treated helical gear speed reducer. Maximum space for vertical model only 16 5/16" x 21½" x 11½". Other models equally compact.



simple, accurate operation

14-turn handwheel on Speedial indicator gives you stepless, accurate speeds from 3 to 4660 rpm's—within a 2:1 to 10:1 speed range. Electric remote or automatic controls also available.

versatile application

Select your *exact* needs from 112 assemblies: ¼, ½ or ¾ hp. units; horizontal left or right, vertical, or 45° left or right models; horizontal or vertical down output shaft.

Write Dept. K19b-M543 for complete bulletin

REEVES PULLEY COMPANY • Columbus, Indiana
Division of RELIANCE Electric and Engineering Co.

TAYLOR Laminated Plastics Vulcanized Fibre

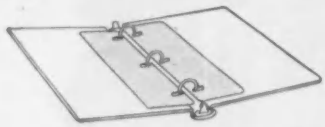
Shop Talk

TAYLOR FIBRE CO.

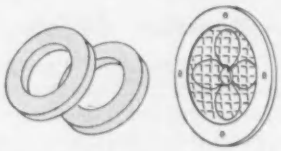
Plants in Norristown, Pa. and La Verne, Calif.

PHENOL—MELAMINE—SILICONE—EPOXY LAMINATES • COMBINATION LAMINATES • VULCANIZED FIBRE • POLYESTER GLASS ROD

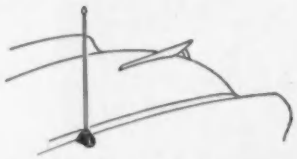
Tips for designers



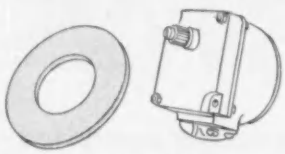
Flippers for loose-leaf binders are made of economical Taylor Vulcanized Fibre . . . affording added rigidity and good protection for the paper pages.



Large exhaust fans use Taylor Paper Base Phenolic washers to help absorb thrust . . . an inexpensive arrangement, with long life.



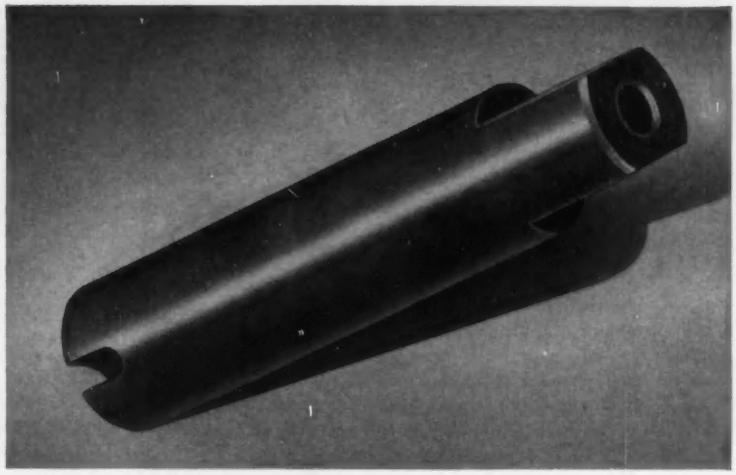
Radio antennas for the colorful, new cars may be made from equally colorful Taylor Polyester Glass Rod, with a copper wire center.



Self-balancing servo motor has stator case insulator which is cold-punched from 1/64" thick Taylor Paper Base Phenolic Laminate sheet.

VISIT WITH TAYLOR AT THE I.R.E. SHOW

Qualified technical personnel will be on hand in the Taylor booth (#675) at the I.R.E. Show in New York's Kingsbridge Armory, March 19 through 22. Visit with Taylor while you're at the show and discuss your application requirements as well as the latest advancements in high-performance laminates.



This impeller shaft, used in the famous Hotpoint Dishwasher, is easily and economically fabricated from Taylor Paper Base Phenolic Tubing.

Fabrication ease holds down costs —when you use Taylor laminates

Economy-minded designers and production managers are discovering plus qualities in the excellent fabricating properties of Taylor phenol, melamine, silicone and epoxy laminates. In addition, the large sheet size and choice of forms in which these materials are supplied make for further economy in utilization . . . through maximum yield of purchased stock.

This outstanding ease of fabrication is not happenstance . . . for all Taylor laminates are the result of resin formulations and production techniques designed to facilitate economical conversion to completed parts. Punching, staking, milling, sawing, drilling . . . you'll find it's easier when you use a Taylor basic material.

Included in the broad selection of Taylor laminates are a great variety of different bases and different grades . . . each with its own combination of electrical and physical properties, qualifying it for a specific application at a reasonable price.

And, here's another *plus!* Your production problems can be simplified . . . schedules safeguarded . . . inventory headaches cured . . . and overall costs reduced . . . by having your finished parts prepared to your specifications in the Taylor Fabricating Division. Valuable experience coupled with complete facilities are ready to serve you. Call on Taylor for a discussion of your particular requirements.

...and cuts the size and weight of cable

Federal's miniature coaxial cables—about ¼ the size of comparable RG types—save critical space and weight in aircraft and instrument uses.

Challenged by the high temperature and minimum weight requirements of jet aircraft and guided missiles, Federal has designed RG cables that perform perfectly at a blistering 500° F.! New Federal miniature coaxials have a top temperature rating of 150° C. . . . up to 200° C. with an impregnated fiber glass jacket!

The key to these new cable developments lies in advanced designs.

Based on utilization of "Teflon," this superior dielectric maintains its excellent low loss and high voltage characteristics through a temperature range of 500° F. to −100° F. "Teflon" has no measurable water absorption; it is chemically inert . . . unaffected by alkalies, acids, aromatic fuels, aromatic organic solvents, and highly corrosive aviation hydraulic fluids.

If your cable problems involve heat, space or weight, it will pay you to consider Federal's new "Teflon" insulated cables. For information, write Dept. D-942

"TEFLON" HIGH TEMPERATURE CABLES

RG-87A/U 50 ohms; 69.5% V.P.; 29.5 mmfd/ft. Cap; 4,000 operating volts.

RG-140/U 75 ohms; 69.5% V.P.; 29.5 mmfd/ft. Cap; 1,700 operating volts.

RG-141/U 50 ohms; 69.5% V.P.; 29.0 mmfd/ft. Cap; 1,500 operating volts.

"TEFLON" MINIATURE COAXIAL CABLES

K-256 50 ohms; 29 mmf/ft. Cap; 72% V.P.; 850 V rms Corona; 13 db/100 ft. Atten. at 400 mc; 0.095 O.D. dielectric; 7/30 silver-plated Copperweld conductor; 0.135 O.D. jacket.

K-257 70 ohms; 21 mmf/ft. Cap; 72% V.P.; 850 V rms Corona; 14 db/100 ft. Atten. at 400 mc; 0.095 O.D. dielectric; 7/34 silver-plated Copperweld conductor; 0.135 O.D. jacket.

K-258 93 ohms; 16 mmf/ft. Cap; 72% V.P.; 850 V rms Corona; 15 db/100 ft. Atten. at 400 mc; 7/38 silver-plated Copperweld conductor; 0.135 O.D. jacket.

"TEFLON" HOOK-UP WIRE—Type E, EE and FF Hook-Up Wires meet MIL-W-16878A. Available in all standard colors.

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FEDERAL TELEPHONE & RADIO FTR

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Slotted Headless

Socket

Here's just one of these set screw ideas!
. . . up to
10 TIMES FASTER APPLICATION
using special unit* with NEW **HOPPER-FED SET SCREWS**

* Pat. No. 2,638,945, Others Pending

Can be used with all metals and with plastic products or parts. Reduces floor loss and cross-threading to a minimum. For free demonstration at our plant, write your name and address in margin and mail ad to us today.

you can obtain the SETKO **JEWEL CASE** of **SET SCREW IDEAS** without cost or obligation

Contains over 30 different samples of the latest developments in set screws for you to examine—study—and try out. To have the Setko "Jewel Case" sent to you on loan, without cost or obligation, simply write your name and address in the margin, tear out this advertisement and mail to us.

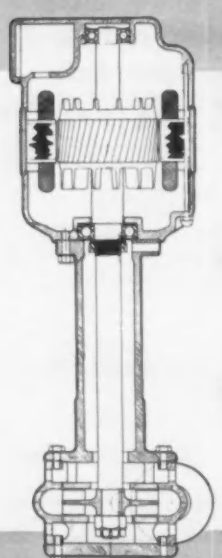
10622P

Set Screw & Mfg. Co. 153 Main St., Bartlett, Ill. (Chicago Suburb)

We specialize in Solving Puzzling Set Screw Problems

Please check whether you want ( ) Demonstration or ( ) Jewel Case

Take a Good Look
AT THE **Ruthman** Gusher Coolant Pumps



SIMPLE DESIGN

Gusher Coolant Pumps are designed so that they require no packing, foot or relief valves. They consume less power when throttled and there is no metal-to-metal contact in the pump, insuring long life with minimum attention.

RUGGED CONSTRUCTION

All castings have been strengthened through time-tested operation. The one-piece shaft is precision ground, which rotates on heavy-duty precision ball-bearings.

DEPENDABLE PERFORMANCE

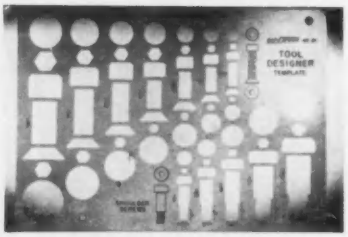
The entire rotating shaft is dynamically balanced to eliminate vibration and wear. Pre-lubricated ball-bearings with surplus grease pocket require no further attention. Your Gusher is always primed . . . ready to deliver coolant in a split second.

THE **RUTHMAN** MACHINERY CO.

1818 Reading Road Cincinnati, Ohio

Weight is approximately 125 lb in cabinet. Dimensions are 19½ x 15¾ x 13¾ in. high. Perkin Engineering Corp., 345 Kansas St., El Segundo, Calif.

For more information—
Circle 82, inside back cover



Drafting Templates

A drafting template contains symbols of tool design elements, such as front and top elevations of socket, cap, countersunk and shoulder screws, as well as stripper bolts. Another template, for structural cross-sections, has 43 cut-out symbols of I-beams, broadflanged I-beams, channels and angles from 2 to 18 in. This template is available in either 1 or ¼ in scale. A. Lawrence Karp, 16 Putnam Park, Greenwich, Conn.

For more information—
Circle 83, inside back cover

Adhesive Applicator

This pliable plastic pen ejects a dot of rubber cement each time it is tapped on a surface where cement is desired. It comes equipped with a cap. It is said to hold enough adhesive to make about 5000 dots. Re-

(Continued on page 296)

In over 100 places, Enjay Butyl rubber parts

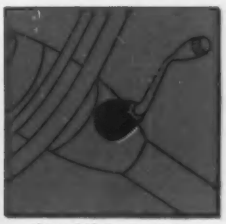
add to Pontiac performance

Axle bumper

Body seals, gaskets, insulators, pads, grommets, etc.

Brake and accelerator pedal pads, bellows

Radiator and heater hoses, ducts



Gearshift lever cover

Pontiac has been using parts made of Enjay Butyl since 1946. The great '56 model now incorporates more than 100 parts made from this super-durable rubber, adding to its performance, style and value. These parts have amazing resistance to deterioration and will easily last the life of the car.

Among the many advantages of Enjay Butyl are *price* and *ready availability*. And it is now available in non-staining grades for white and light-colored parts. Extensive laboratory and testing facilities are at your service. For the full story, contact the Enjay Company today.

ENJAY BUTYL

Enjay Butyl is the super-durable rubber with *outstanding* resistance to aging • abrasion • tear • chipping • cracking • ozone and corona • chemicals • gases • heat • cold • sunlight • moisture

ENJAY **ENJAY COMPANY, INC.,** 15 West 51st Street, New York 19, N. Y.
District Office: 11 South Portage Path, Akron 3, Ohio

36 SUCCESSFUL YEARS OF LEADERSHIP IN SERVING INDUSTRY

NEW ONAN SHORT-STROKE ENGINES

deliver more horsepower-hours per dollar!

Add the many powerful sales features of ONAN long-life power to your equipment... at no extra cost!

Onan engines are designed and built for continuous service . . . primarily as power for Onan portable electric plants. The severe requirements of this service call for an engine that is capable of running hundreds and even thousands of hours with minimum servicing . . . an engine that is compact in all dimensions, smooth-running and light in weight.

This particular combination of design characteristics *is not available on other types of engines now in quantity production.* If the engine requirements for your equipment are severe, an Onan engine can give it improved performance and *saleability.* Even on equipment where an Onan engine may be better than specifications call for, it deserves consideration because you can buy Onan engines at prices comparable to general-purpose engines *and add sales features to your product at no extra cost.*

The inherent smoothness of horizontally-opposed, alternate-firing design gives Onan two-cylinder models important *saleable* advantages in many applications.

Onan air-cooled engines are today giving outstanding performance *and sales appeal* to many types of equipment including portable welders, engine-driven air conditioners, truck refrigeration units, pumps and construction equipment. The premium performance of Onan engines can give your equipment the same kind of competitive advantage. We invite consultation by mail or telephone. (Call Minneapolis . . . FE 2-1155.)

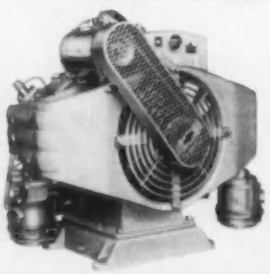
MODEL CCK 12.9 H.P., gasoline-powered

Horizontal, two-cylinder opposed, 4-cycle. Develops 12.9 H.P. at 2700 R.P.M. 3¼" bore; 3" stroke; 50 cubic-inch piston displacement; 5.5:1 compression ratio. High tension magneto ignition; governor regulation within 5%. Removable aluminum cylinder heads. Full pressure lubrication. Pull-rope or recoil starter. Weighs 148 lbs.

MODEL DRP

15 H.P., Diesel-powered

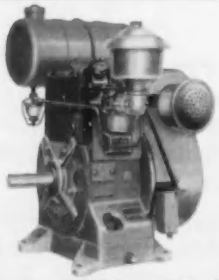
Horizontal, two-cylinder opposed; develops 15 H.P. with accessories at 2300 R.P.M. 4-cycle; 3½" bore; 3½" stroke; 67.3 cubic-inch piston displacement; 17.3:1 compression ratio. Solid injection, full Diesel. Forged steel crankshaft and connecting rods. Full pressure lubrication; 12-volt generator. Electric starting. Weighs 516 pounds.



MODEL AJ

5.5 H.P., gasoline-powered

Develops 5.5 H.P. at 3600 R.P.M. Four-cycle; 2¾" bore, 2½" stroke; 14.9 cubic-inch piston displacement; 6.25:1 compression ratio. Removable aluminum-alloy cylinder head; fully counter-weighted and balanced crankshaft. High tension magneto ignition. Manual pull-rope starting. (Recoil starter or electric starting available.) Weighs 78 pounds.



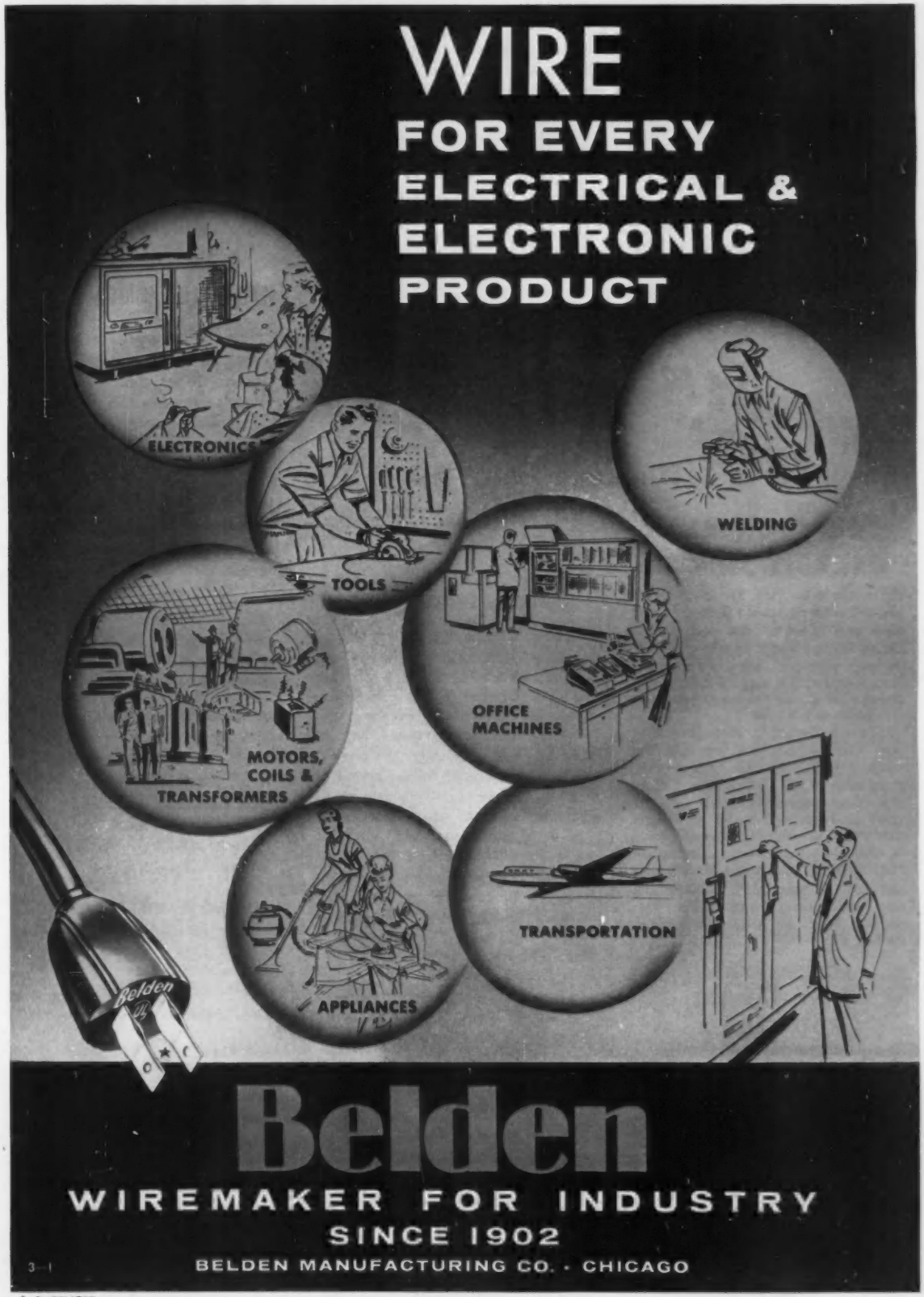
Write for Complete Specifications!

D. W. ONAN & SONS INC.

4028 University Ave. S.E., Minneapolis 14, Minnesota

ONAN AIR-COOLED ENGINES

WIRE
FOR EVERY ELECTRICAL & ELECTRONIC PRODUCT



Belden
WIREMAKER FOR INDUSTRY
SINCE 1902
3-1
BELDEN MANUFACTURING CO. · CHICAGO

★ PATENTED

DON'T GIVE ME THAT!

YOU CAN'T BEAT GARRETT SERVICE

I'm not a wise guy, but I do know about the service these Garrett plants give you. Seems hard to believe. Those fellows bend over backwards to help you out in an emergency. And their regular service means you always get deliveries when promised ... sometimes before.

Of course, when it comes to quality they are tops on lock washers, flat washers, spring washers, hose clamps, stampings and assemblies. They have three plants equipped with the most modern high-speed automatic machinery to turn out billions of parts to exact specification . . . complete heat treating, plating and finishing facilities. If you don't believe me, next time send your order into Garrett. You'll see why their customers say YOU CAN'T BEAT GARRETT.

LOCK WASHERS
FLAT WASHERS
HOSE CLAMPS
STAMPINGS

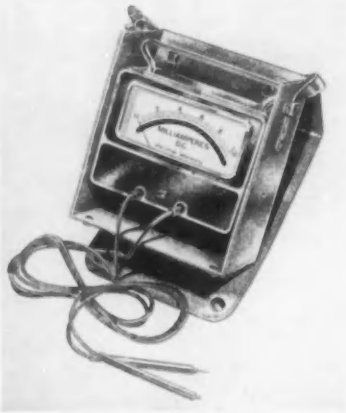
Manufactured by

GEORGE K. GARRETT CO., Inc.
Philadelphia 34, Pa.

Garrett
OF PHILADELPHIA

fills are available in throw away plastic ampoules. To refill, the top is unscrewed and the adhesive is poured in. Dept. PE, Poppet Corp., 8707 Hudson Blvd., North Bergen, N. J.

For more information—
Circle 84, inside back cover



Portable Laboratory Instruments

These self-contained, portable instruments are available in 38 standard ranges with a rated accuracy of either 0.5 or 1 per cent of full scale deflection. An incorporated overload network provides meter protection up to 500 times full scale value.

These instruments come complete with leather carrying case, calibration chart, probes, and feature metal cases, double magnetic shielding, mirrored scales and double probe outlets (cords may be plugged into low resistance jacks on the face, or used with the three-way binding posts). Dimensions: 7½ x 6⅝ x 3¾ in. Phaostron Instrument and Electronic Co., 151 Pasadena Ave., S. Pasadena, Calif.

For more information—
Circle 85, inside back cover

High Temperature Strain Gage Kit

The strain gages are offered for experimental use without guarantees and are available in kits including ten gages, four types of cement with different temperature limits, detailed instructions for use, and tools to simplify application.

Gages consist of an etched foil grid

(Continued on page 301)

APOLLO

pre-finished metals

stainless steel
steel • copper
brass • zinc
aluminum

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Here is the modern low-cost short cut to greater beauty for your product and increased economy for your manufacturing operations.

APOLLO sheets, strips and coils... metallic, mechanical or enameled finishes . . . can lower your production costs up to 50% compared to piece-plating and individual finishing methods.

APOLLO'S high production facilities are geared to cost economy... to provide you the widest possible variety of finishes and surfaces for practically unlimited applications.

APOLLO Pre-Finished Metals are readily fabricated in accordance with all sheet metal and machine shop practices.

Ask about our "drawing board to finished product" service. Request bulletin, *How to Put the Pre-Finishing Touch on Greater Profit!*

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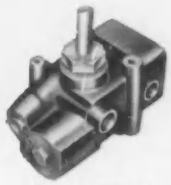
A FEW OF THE new

VICKERS®

AIRBORNE HYDRAULIC VALVES

Hydraulic Motor with Anti-Overrun Flow Control



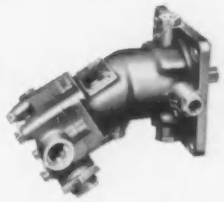
Constant Gain Nose Wheel Steering Valve

from New "Concept-through-Production" Facility at El Segundo Division

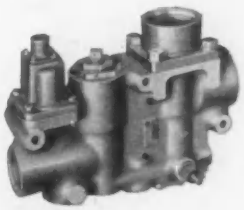
The valves shown are representative of an expanding line being built to meet rapidly advancing airborne requirements. They were developed in close cooperation with the airframe and power plant engineers who are using them. They are products of Vickers El Segundo (California) Division, which has complete engineering, laboratory and production facilities for "concept-through-production" of airborne hydraulic valves.

Thoroughly experienced in the requirements of aircraft systems and working closely with the Detroit organization, the El Segundo staff can quickly solve new problems in design. As soon as the prototype is approved, it becomes a production item in minimum time. Ask the nearest Vickers Application Engineer for further information or write for Bulletin A-5209.

Flow-Sensitive Pressure Regulator



Motor with Constant Speed Valve



Pump Control Valve

Relief Valve with Thermal Protection

Power Control Flow Regulator

VICKERS INCORPORATED

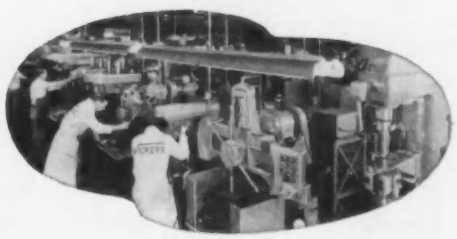
DIVISION OF SPERRY RAND CORPORATION

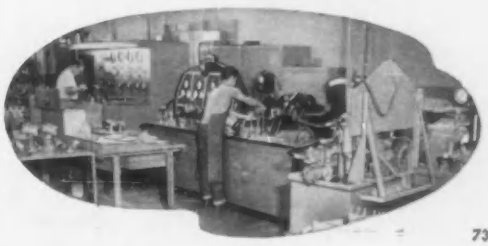
1454 OAKMAN BLVD. • DETROIT 32, MICH.

Application Engineering and Service Offices:

El Segundo, California, 2160 E. Imperial Highway • Arlington, Texas, P.O. Box 213 • Detroit 32, Michigan, 1400 Oakman Blvd. • Washington 5, D. C., 6247 Wyatt Bldg. *Additional Service facilities at:* Miami Springs, Florida, 641 De Soto Drive **TELEGRAMS: Vickers WUX Detroit • TELETYPE "TWX" DE89 • CABLE: Videt Detroit • Overseas Representative: The Gyroscope Co., Ltd.—Great West Road, Brentford Middx., England. Engineers and Builders of Oil Hydraulic Equipment since 1921.**

Design, Development, Testing and Manufacturing at El Segundo Division of Vickers Incorporated.





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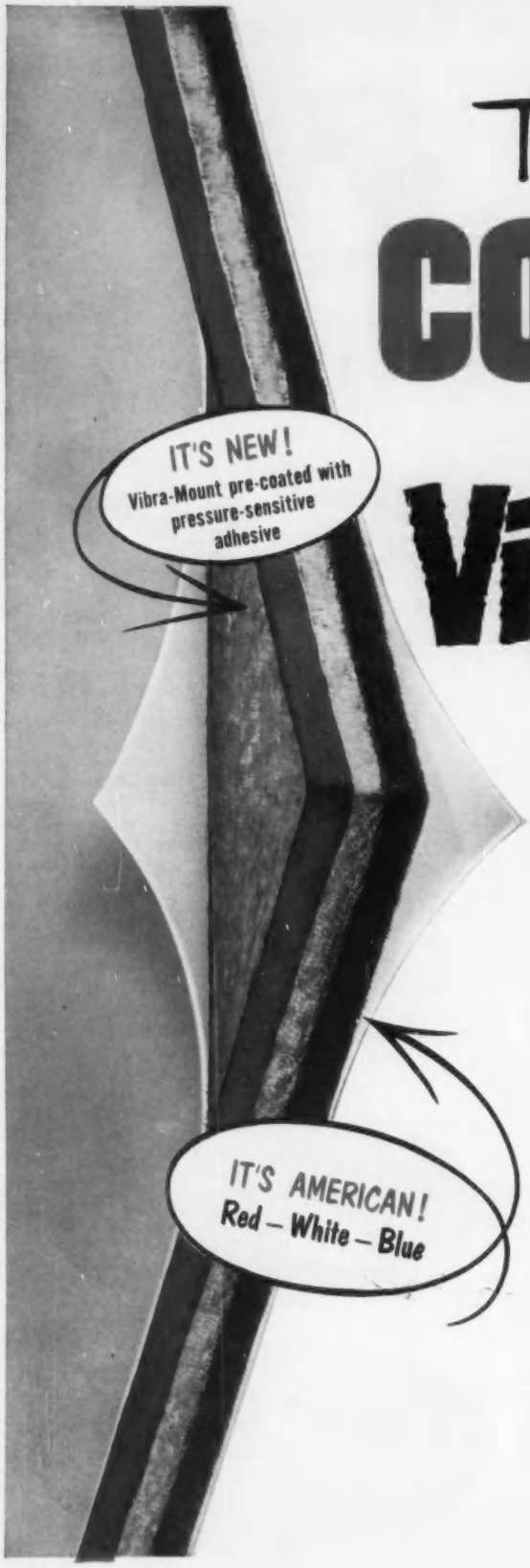

This FELT can CONTROL that Vibration!

When machinery has the shakes, put it on Vibra-Mount* Felt. This resilient cushion greatly reduces the amount of vibration transmitted to the floor, as much as 85%. People are happier, buildings safer. Vibra-Mount Felt is long lived because it takes compression with a minimum of set. In almost every case lag bolts are unnecessary, so machines can be rearranged with a minimum of difficulty. Write for FREE booklet, "How to Reduce Vibration." For technical information, ask for Data Sheet No. 10.

*T. M. Reg.

American Felt Company

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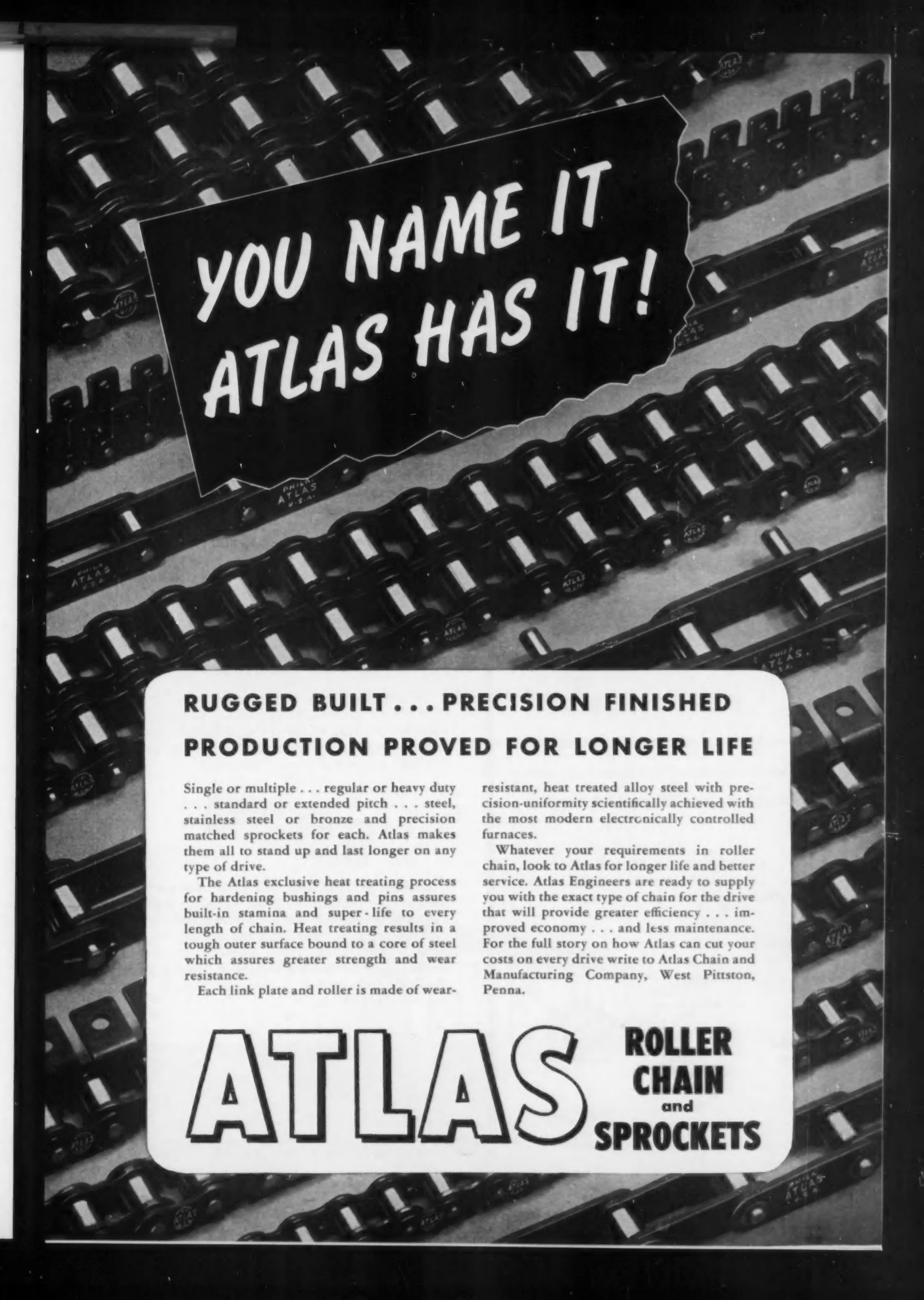
GENERAL OFFICES: 78 GLENVILLE ROAD, GLENVILLE, CONN.

SALES OFFICES: New York, Boston, Chicago, Detroit, Cleveland, Rochester, Philadelphia, St. Louis, Atlanta, Greenville, S. C., Dallas, San Francisco, Los Angeles, San Diego, Portland, Seattle, Montreal.—PLANTS: Glenville, Conn.; Franklin, Mass.; Newburgh, N. Y.; Detroit, Mich.; Westerly, R. I.—ENGINEERING AND REASEARCH LABORATORIES: Glenville, Conn.



RUGGED BUILT . . . PRECISION FINISHED

PRODUCTION PROVED FOR LONGER LIFE

Single or multiple . . . regular or heavy duty . . . standard or extended pitch . . . steel, stainless steel or bronze and precision matched sprockets for each. Atlas makes them all to stand up and last longer on any type of drive.

The Atlas exclusive heat treating process for hardening bushings and pins assures built-in stamina and super-life to every length of chain. Heat treating results in a tough outer surface bound to a core of steel which assures greater strength and wear resistance.

Each link plate and roller is made of wear-resistant, heat treated alloy steel with precision-uniformity scientifically achieved with the most modern electronically controlled furnaces.

Whatever your requirements in roller chain, look to Atlas for longer life and better service. Atlas Engineers are ready to supply you with the exact type of chain for the drive that will provide greater efficiency . . . improved economy . . . and less maintenance. For the full story on how Atlas can cut your costs on every drive write to Atlas Chain and Manufacturing Company, West Pittston, Penna.

ATLAS ROLLER CHAIN and SPROCKETS

RICHARDSON

helps improve molded auto parts

Each of the molded parts pictured here had specifications which called for special materials often with unusual properties. All called for creative design approaches, both by customer and Richardson.

Richardson engineers, specialists in both molded and laminated plastics, will welcome the opportunity to help you. Write or phone for additional information.

THE RICHARDSON COMPANY
FOUNDED 1858
2793 Lake St., Melrose Park, Ill. (Chicago District)

MELROSE PARK, Ill.

INDIANAPOLIS, IND.

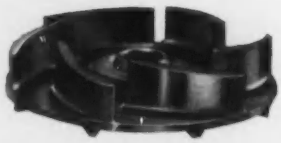
NEWNAN, GA.

OGDEN, UTAH

SALES OFFICES IN PRINCIPAL CITIES

NEW BRUNSWICK N. J.

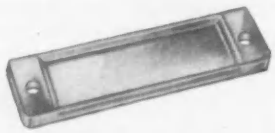
TYLER, TEXAS



. . water pump impeller A special moisture resistant phenolic was specified for this part which must withstand the extremes of both high heat and intense cold, as well as strong torque action plus corrosion and cavitation resulting from the circulation of water in the car's cooling system.

. . timing gear The molded blank of this gear had to have high flexural characteristics . . also a good bond in the laminate section for ease in cutting gear teeth, and to insure necessary tooth strength. The manufacturer and Richardson developed a new material with high heat resistance. Result: Fine flexural strength in the web section . . more quiet operation . . . easier fabrication . . . easier assembly . . . *tripled gear life!*

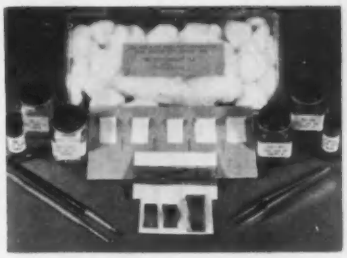
. . radio antenna mast base This part had to have good surface appearance, high impact strength, high dielectric strength, and at the same time be weather resistant. A black phenolic material with an attractive high gloss finish was recommended.



. . dashboard light lens Originally this part was designed as a clear lens. Later, when the specifications were changed to call for a translucent lens, the customer suggested that either the mold, or the clear parts, be sandblasted. . either process would have increased costs. Richardson suggested, instead, a special light-transmitting polystyrene. Result: 15% reduction in lens cost.

RICHARDSON PLASTICS

MOLDED AND LAMINATED



0.0005 in. thick on a temporary carrier, which is stripped off when applying them, leaving the grid embedded in a ceramic cement. Nichrome, Nichrome V, and Constantan grids are available in gage lengths of ½, 1, and ⅜ in. Temperature limits of the four cements are 700, 900, 1100, and 1800 F. Tests indicate that the gages can be used only for dynamic tests. Nominal resistance of the gages is between 97 and 120 ohm. Baldwin-Lima-Hamilton Corp., Philadelphia 42, Pa.

For more information—
Circle 86, inside back cover

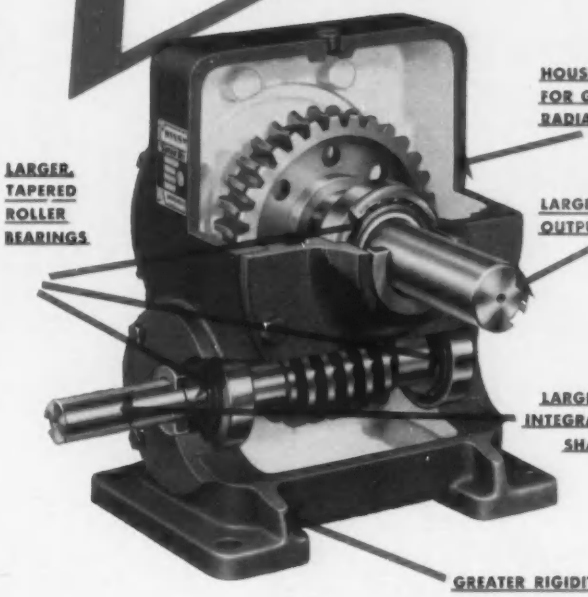
Self-Contained Mechanical Seal

A series of unitary mechanical seals, originally designed for use on process pumps, has been announced.

According to the manufacturer, these seals are a single unit, including sleeve and gland. No on-the-job measurements or adjustments are necessary. There are no setscrews to loosen, corrode or damage shaft or shaft sleeve. Lock and drive are external, making them readily accessible. The gland has circulating connections to provide cool, clean lubrication. All sealing faces are precision lapped. All high pressure seals are pressure balanced. Garlock Packing Co., Palmyra, N. Y.

For more information—
Circle 87, inside back cover

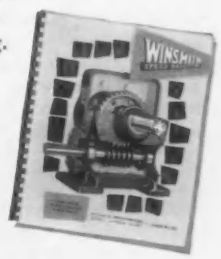
1 CHECK POINTS of Speed Reducer Design


HOUSING DESIGNED FOR GREATER HEAT RADIATING CAPACITY
LARGER, TAPERED ROLLER BEARINGS
LARGER, STRONGER OUTPUT SHAFTS
LARGER STRONGER, INTEGRAL WORM SHAFTS
GREATER RIGIDITY

...on the New "C" WINSMITH SERIES

THESE 5 IMPROVED FEATURES of Winsmith's new "C" Series reducers mean greater performance, greater stamina, greater dependability...*greater value for your horsepower dollar.*

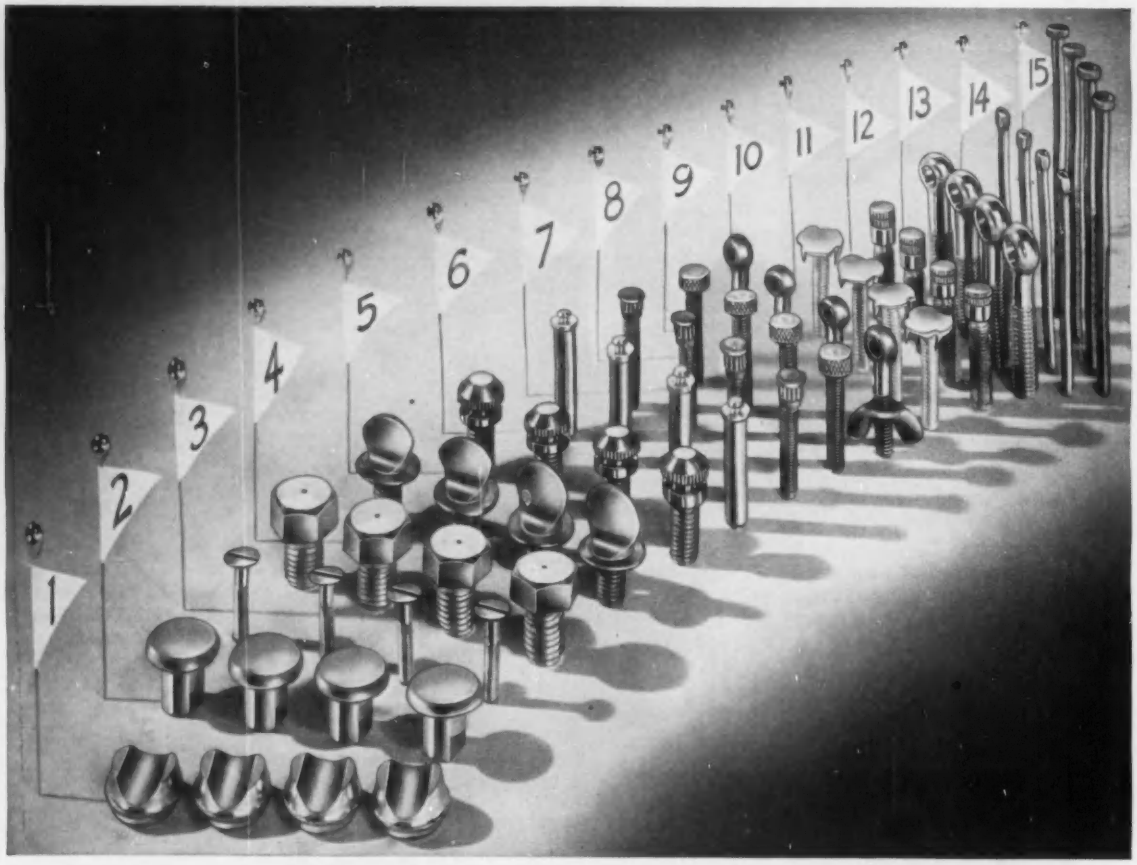
In all, 108 models comprised of single and double reduction units are available in the "C" Series...a unit to answer every speed reducer need. Compare our *increased* rated horsepower and torque output with reducers of competitive makes. For complete data on the "C" Series, write for catalog.



WINSMITH SPEED REDUCERS

NEW CATALOG! Describes the complete "C" Series plus other units in the Winsmith line. Contains drawings, dimensions, weights and ratings for each model described. Write today for Catalog No. 155—on company letterhead, please.

WINSMITH, INC. 111 Eaton St., Springville, (Erie County), N.Y.



This Army of Specials Marches to Save You Money

Here are a few of the many specials produced by Harper to save industry money—to do a better job.

Many used to be milled from bar but Harper engineers and metallurgists developed methods of cold-forming them with these results:

- Important savings in cost
- Faster production
- No metal wasted
- Usually a cleaner, stronger, better finished product

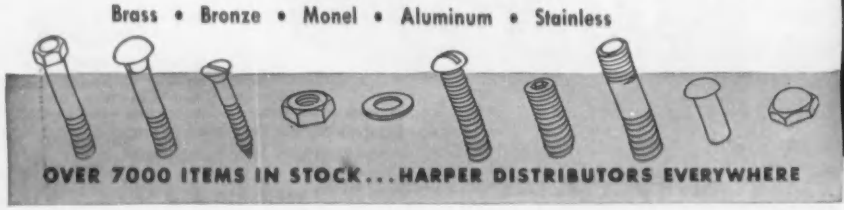
If you are using parts like these of any metal other than plain steel in quantity, it will pay you to check with Harper no matter how you are producing them.

Remember also that Harper is the largest manufacturer specializing in standard bolts, nuts, screws, washers and rivets of all non-ferrous metals and stainless steel. Stocks available in every market area for immediate delivery. Check the Harper branch or distributor near you.

THE H. M. HARPER COMPANY
8203 Lehigh Avenue, Morton Grove, Ill.

Specialists in all corrosion-resistant fastenings
Bolts • Nuts • Screws • Rivets • Washers
of
Brass • Bronze • Monel • Aluminum • Stainless

1. Copper Contact
2. Copper Lead
3. Brass Hi-torque Brake Band Bolt
4. Aluminum Hex Head Air Pressure Bolt
5. Silicon Bronze Transformer Adjusting Screw
6. Silicon Bronze Terminal
7. Stainless Steel Groove Pin
8. Silicon Bronze Molded Plastic Insert
9. Stainless Steel Focusing Screw
10. Stainless Steel Hinge Pin
11. Brass Hold-down Screw
12. Brass Terminal Block Screw
13. Monel Eye Bolt
14. Copper Conductor Pin
15. Stainless Steel Hex Head Stem Bolt



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HARPER
EVERLASTING FASTENINGS

. . . the solution to your Lubrication problem is here . . . PUREBON

Carbon-graphite especially designed for mechanical applications.

For complete information about PUREBON. Write for Bulletin 52

Purebon is the designer's solution to many knotty problems involving sliding or rotating parts where lubrication is difficult and sometimes impossible. Purebon parts are molded or machined exactly to our customers' specifications here in our own plant, under our close supervision and inspection. *Because of the diversified characteristics of Purebon, applications are limited only by the designer's imagination.* If you have a problem involving insufficient lubrication at critical points of friction, our design engineering department will be happy to work with you toward its swift and successful solution.

COMPRESSOR BLADE
(2/3 SIZE)

PUREBON'S PROPERTIES

1 **MOLDED TO SIZE—FOR MANY APPLICATIONS**
Tolerances of approximately 1½% of dimension required for molding most shapes.

2 **SELF-LUBRICATING—OR BY THE MATERIAL HANDLED**
Varies with grade of Purebon.

3 **STRONG AND TOUGH**
Transverse strength varies from 4,000 to 13,000 lb./sq. in. according to grade.

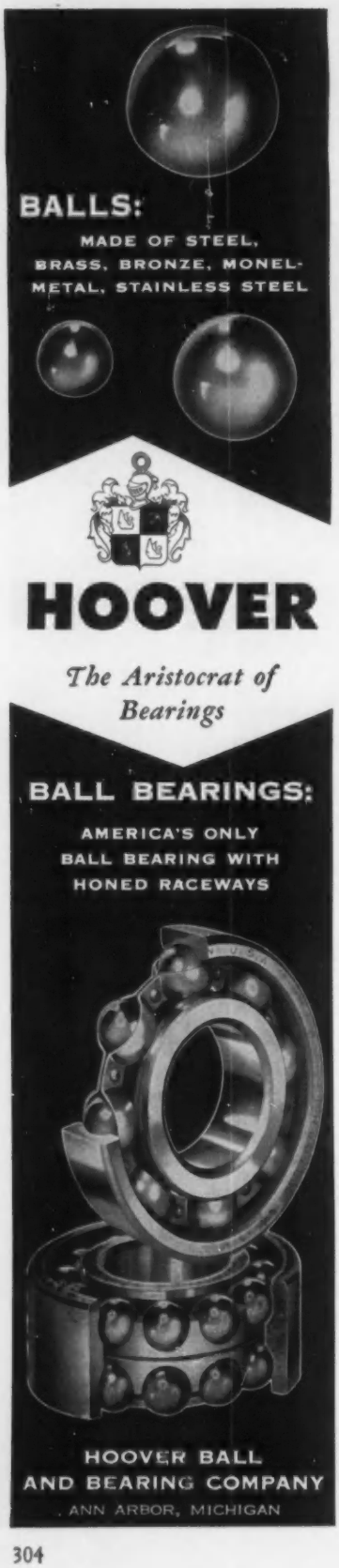
4 **READILY MACHINABLE**
Tolerances as close as .0005 can be maintained where required.

5 **CHEMICALLY INERT—NON-TOXIC**
Resistant to attack by chemicals of all kinds, used in food handling and processing equipment.

6 **HIGH TEMPERATURE APPLICATION**
Most Purebon grades will operate efficiently in temperatures up to 700°F in air or much higher in neutral or reducing atmosphere.

Leaders for over 40 YEARS in PURE CARBON PRODUCTS

PURE CARBON CO., INC.
448 HALL AVENUE
ST. MARYS, PENNSYLVANIA



CATALOGS and BULLETINS

To obtain copies of literature described below, circle corresponding number on postcard inside back cover. For those catalogs and bulletins available only when requested on company letterhead, see page 315.

Speed Reducer–Bulletin, 7pp, describes line of infinitely variable reducers of 10 to 100 in-lb torque ratings. Revco, Inc., 2 E. Franklin Ave., Minneapolis 4, Minn.

Circle 88, inside back cover

Hydraulic Power Transmission–Bulletin 145-B, 4 pp with specification sheets inserted, describes device that can be used with electric motors or internal combustion engines of ¾ to 50 hp. Twin Disc Clutch Co., Hydraulic Div., Rockford, Illinois.

Circle 89, inside back cover

PVC Pipe and Fittings–Bulletin PE-40, 11 pp, gives physical properties, uses and specified dimensions. Corning Glass Works, Corning, N. Y.

Circle 90, inside back cover

Constant-Force Compression Spring–Bulletin 313A-1-55, 16 pp, discusses characteristics and properties of the spring, materials, types of ends, methods of mounting, design formulas, and design standards. Hunter Spring Co., Lansdale, Pa.

Circle 91, inside back cover

Beryllium Copper Strip–Bulletin 6, 12 pp, offers suggestions for ordering beryllium copper strip. Includes discussion of available alloys, tempers, sizes and tolerances with tabular data on properties. Penn Precision Products, Inc., 501 Crescent Ave., Reading, Pa.

Circle 92, inside back cover

Magnetostriction Transducers–Booklet, 38 pp, summarizes all practical experiments to guide the engineer toward a workable design in exploring new fields in the sonic and ultrasonic regions. A magnetostrictive transducer is used to convert electrical input energy to mechanical output energy or mechanical input energy to electrical output energy. International Nickel Co., Inc., 67 Wall St., New York 5, N. Y.

Circle 93, inside back cover

Hose Assemblies–Catalog S-1, 8 pp, shows line of swaged hose, hose ends and adapters. Weatherhead Co., 128 W. Washington Blvd., Fort Wayne, Ind.

Circle 94, inside back cover

High Temperature Rectifiers–These selenium rectifiers are capable of operating at plate temperatures of 150 C, without derating. Development of a new artificial barrier layer and counter electrode has resulted in permitting operation to very nearly the intrinsic and sublimation temperature of selenium. Sarkes Tarzian, Inc., 415 N. College Ave., Bloomington, Ind.

Circle 95, inside back cover

Aluminum Products–Booklet, 8 pp, describes extruded shapes, structurals, machining stock, drawn tube, forging stock, press forgings, impact extrusions, screw machine products, heavy press extrusions. Harvey Aluminum, 19200 S. Western Ave., Torrance, Calif.

Circle 96, inside back cover

O-Rings–Data sheet 103, 6 pp, provides detailed specifications of silicone rubber O-rings. Bacon Industries, Inc., 192 Pleasant St., Watertown, Mass.

Circle 97, inside back cover

Aluminum Hand Forgings–Folder, 6-pp, tabulates tensile and yield strengths and elongation percentages of hand forgings made from aluminum alloys 2014-T6 and 7075-T5 in various sizes up to 2000 lb in weight. Kaiser Aluminum & Chemical Sales, Inc., 1924 Broadway, Oakland, Calif.

Circle 98, inside back cover

Heat Conducting Cement–Bulletin, 11 pp, describes three thermal conducting cements. These thermal conducting cements are used primarily to improve the heat transfer between tracings and process equipment. They enlarge the contact area between tracing and process equipment, improving

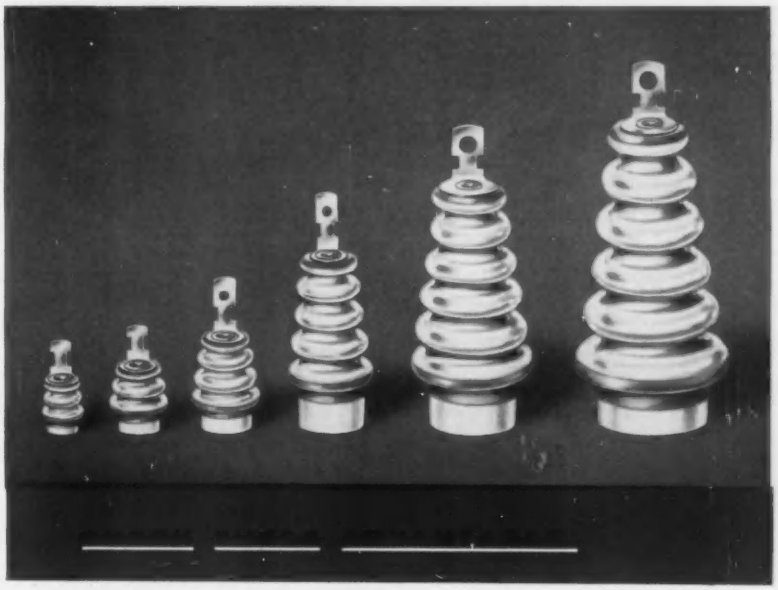
(Continued on page 308)

now...

Frenchtown NICOTE Metallized Terminals!

● After years of extensive research into hermetic seal problems in the electronics and electrical fields, Frenchtown proudly presents this *improved line* of Annuluted Type NICOTE Metallized Hermetic Terminals for use in controls, relays, transformers, capacitors, motors and heater units.

Custom-engineered of HIGH ALUMINA CERAMICS and metallized with Frenchtown's exclusive NICOTE. These terminals are available in six varying sizes with a choice of terminal hardware to fit any exacting application.



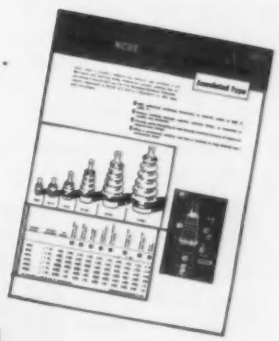
- **Will withstand *continuous* immersion in lead-tin solder at 260°C. (500°F.).**
- **Reduce tracking through superior external shape, so important in smaller size terminals.**
- **Provide easier threading of wire through terminal because of improved *tapered* bore design.**
- **Effect a permanent, positive seal that is resistant to high thermal and mechanical shock.**

VISIT US AT THE SHOW!

We'll be pleased to show you the complete line of Frenchtown NICOTE Metallized Hermetic Terminals at our Booth No. 26, I.R.E. Show, Kingsbridge Palace, March 19-22, 1956.

FOR COMPLETE INFORMATION . . .

. . . send for Engineering Data Sheet 1055 which provides specifications for the complete line of Frenchtown NICOTE Metallized Hermetic Terminals . . . plus engineering details on a wide selection of terminal hardware.



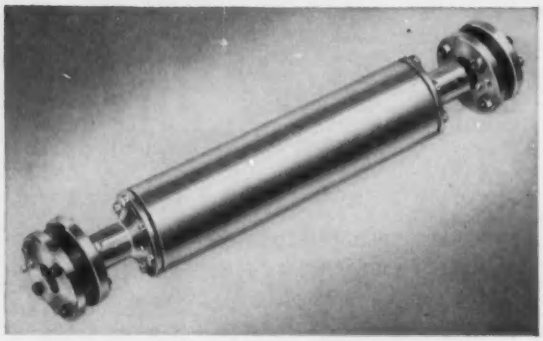
frenchtown PORCELAIN COMPANY

87 MUIRHEAD AVENUE | TRENTON 9, NEW JERSEY

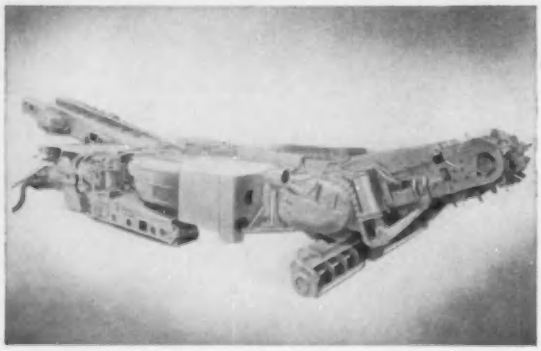
How Rzeppa Joints Solve Critical Drive Problems . . .

Changing or Fixed Angles – High or Low Speeds

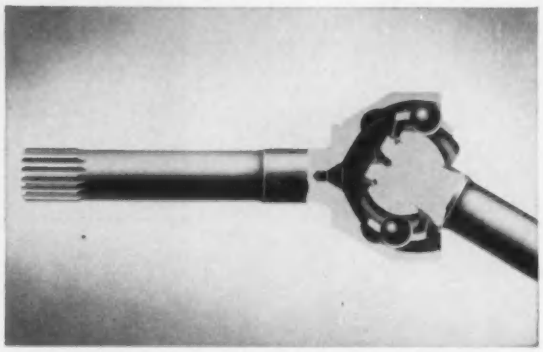
LOW ANGLE — HIGH SPEED Up to 3° at 8,000 rpm. Aircraft uses the Rzeppa disc type for auxiliary power take-off shaft drives because constant torques and speeds are transmitted. This type is especially adaptable to those applications where vibration is critical.



Rzeppa disc type joints are of rugged design. Are available in either spline-driven or bolt-driven types. A flexible neoprene seal permits working angles up to 18°.



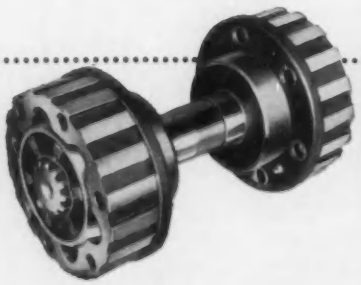
HIGH ANGLE — LOW SPEED Up to 35° at 400 rpm. Continuous miner really uses the versatility of Rzeppa bell type joints. Its working angle is constantly fluctuating. Bell joints are especially suited for power steering drives or articulated driving axles with independent wheel suspension.



Rzeppa bell type joints are constructed with a spline shank. Are easily sealed in axle housings or other machine components. Will handle working angles up to 35° depending on seal types and housings required.

Somewhere between the two applications shown lies the answer to more effective joint performance for you. Because of their versatility, Rzeppa Constant Velocity Universal Joints are transmitting a uniform flow of power in these and hundreds of other applications — including machine tools.

By transmitting true, constant rotating motion, Rzeppa Joints wear longer, have higher capacity, are more compact, and operate with less friction. That's why Rzeppa Joints carry heavier loads for their size than any other type. Disc type or bell type, you get ruggedness and versatility. Don't you, too, have an application that can use these performance advantages? Our catalog may help answer that for you. Send for it today.



TYPICAL DRIVE LINE APPLICATION – Jointed shaft for independently sprung rear axle and propeller shafts for industrial applications.

RZEPPA *Constant Velocity* **UNIVERSAL JOINTS**

Joint Division
THE GEAR GRINDING MACHINE CO.
8939 Christopher, Detroit 11, Michigan

Service problems are minimized in the A.B.C. automatic washer by use of Johnson sintered bronze Ledaloyl self-lubricating bearings.

Altorfer Brothers Company assures customer satisfaction by using Johnson Bearings in its A.B.C. Washers

One way that Altorfer Brothers Company, Peoria, Ill., manufacturer of the A.B.C. line of washers, ironers and driers, gets assurance of customer satisfaction is to install the finest bronze bearings available. Altorfer uses powdered bronze bearings made by Johnson Bronze Company of New Castle, Pa., because they are carefully produced to exact specifications and because they retain enough oil to service the bearings during the life of the washer.

Consider the Ledaloyl sintered bronze bearings which Johnson Bronze makes for use on the A.B.C.-O-Matic washer's shaft and tube. This bearing, one of eight sintered bronze bearings, is the workhorse of the washer and is vital to the operation of the shaft which spins the tub. Johnson Bronze Company has supplied these bearings to Altorfer Brothers since 1950 when the firm first began to make automatic washers.

Altorfer Brothers has used Johnson bearings for other applications since 1928 because of their uniform high quality.

If you have a tough application that calls for long bearing life under rugged conditions, you will want to learn how Johnson Bronze bearings can build more customer satisfaction into your product. If you need it, trained engineering help is available to guide you in choosing the bearings which will lower costs and improve performance. Johnson Bronze Company, 508 South Mill Street, New Castle, Pa.

Johnson Bearings

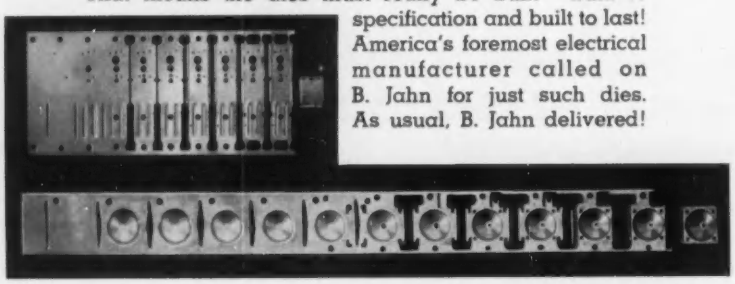
LEDALOYL (powder metallurgy) • BRONZE ON STEEL • ALUMINUM ON STEEL • CAST BRONZE • STEEL AND BABBITT

TO DELIVER THERMOSTAT COMPONENTS BY THE MILE, BY THE MINUTE! PROGRESSIVE DIES by

B. Jahn

Form Intricate Parts Day After Day With Absolute Accuracy and Uniformity!

Thermostat components must be precise—identical —competitively priced—produced by the millions! That means the dies must really be built — built to specification and built to last! America's foremost electrical manufacturer called on B. Jahn for just such dies. As usual, B. Jahn delivered!



Here's a set of die strips that show how progressive dies by B. Jahn really rolled up their sleeves and went to WORK! The 9 station die delivered 60 units per minute; the 12 station die formed 90 components per minute. Both dies delivered mile after mile of intricate parts — with unfailing uniformity and precision. One more example of B. Jahn die making ingenuity and versatility affording increased production at decreased cost.

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B. Jahn

THE B. JAHN MANUFACTURING COMPANY • NEW BRITAIN, CONNECTICUT

the thermal conductivity. Climax Mfg. Corp., 900 Wilmington Road, New Castle, Del.

Circle 99, inside back cover

Polyester Film—Booklet, 7 pp, has commercial uses and detailed physical and chemical properties of Mylar polyester film. E. I. duPont de Nemours & Co., Wilmington 98, Dela.

Circle 100, inside back cover

Stainless Steel Fastenings—Catalog, 64 pp, combines stock lists, price lists and discount sheets in one handy reference manual. Listing includes over 9000 items and sizes in different stainless analyses. Anti-Corrosive Metal Products Co., Inc., Castleton-on-Hudson, N. Y.

Circle 101, inside back cover

Nickel-Plated Steel—Manual, 12 pp, presents a technical description of nickel-plated steel plate products, covering manufacturing techniques and fabrication procedures. Colorado Fuel & Iron Corp., 575 Madison Ave., New York 22, N. Y.

Circle 102, inside back cover

Vibration Hangers—Catalog VIT-55, 4 pp, describes two types of vibration hangers. The rubber-in-shear type consists of a durable, bonded rubber-in-shear isolator spot-welded inside a steel housing. The steel spring type consists of a helical steel spring enclosed in a steel housing. T. R. Finn & Co., Inc., 200 Central Ave., Hawthorne, N. J.

Circle 103, inside back cover

Stationary Tachometers—Bulletin 105, 4 pp, describes line of instruments designed for measuring of machine speeds. Metron Instrument Co., 432 Lincoln St., Denver 3, Colo.

Circle 104, inside back cover

Limit Switch—Bulletin 33, 4 pp, describes operating features of switch and its component parts, designed for machine tools and presses. E. W. Bliss Co., Canton, Ohio.

Circle 105, inside back cover

Shaded Pole A-c Motors—Catalog F 4271, 6 pp, line of shaded pole a-c motors for use in vending machines, appliances, office machines, industrial instruments, projection equipment, servomechanisms, communication equipment, displays, toys and many

(Continued on page 309)

other applications. Describes line of small motors available in undirectional, synchronous, and reversible models with ratings up to 1/20 hp. Barber-Colman Co., 1200 Rock St., Rockford, Ill.

Circle 106, inside back cover

Silicone Products—Booklet, 11 pp, describes almost 150 silicone products, 18 of which were first introduced within the last 12 months. Dow Corning Corp., Midland, Mich.

Circle 107, inside back cover

Roller Bearings—Booklet, 8 pp, describes line of bearings having cages which keep rollers spaced out and aligned at their pitch circle. Roller Bearing Co. of America, Sullivan Way, W. Trenton, N. J.

Circle 108, inside back cover

Steel Sheet and Strip—Bulletin EM 21, 28 pp, gives information on electrical steels as well as detailed information as to gage, performance guarantees and detailed graphs on various technical aspects of these steels. Allegheny Ludlum Steel Corp., 2020 Oliver Bldg., Pittsburgh 22, Pa.

Circle 109, inside back cover

Electric Motors—Booklet, 10 pp, describes line of motors, $\frac{1}{8}$ to 400 hp, of various types; open, enclosed, variously mounted. Century Electric Co., 1806 Pine St., St. Louis 3, Mo.

Circle 110, inside back cover

Molded Teflon—Brochure contains illustrations of applications of Teflon as cup, ball or shaft seals, washers, gaskets and diaphragms. Sparta Mfg. Co., Dover, Ohio.

Circle 111, inside back cover

Mercury Safety Switches—Bulletin 800, 2 pp, describes line of switches for hazardous and corrosive atmospheres. Industrial Automation Corp., 2415 W. Montrose Ave., Chicago, Ill.

Circle 112, inside back cover

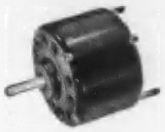
Metal Hose—Catalog 152, 12 pp, describes range of flexible metal hose products, along with coupling data. Flexonics Corp., 1351 S. 3 Ave., Maywood, Ill.

Circle 113, inside back cover

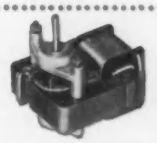
Tubing for Sub-Zero Temperatures—Bulletin TB-357, 6 pp, provides information pertaining to tubular products

(Continued on page 312)

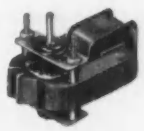
ENDURING
AS AN ELEPHANT!



MODEL B
4-pole, 4-coil shaded pole AC Induction Type



MODEL A
2-pole, shaded pole AC Induction Type



MODEL C
2-pole, shaded pole AC Induction Type

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FRACTIONAL HP. MOTORS
1/40 HP. to 1/1100 HP.

Dependable power for years of trouble-free performance is a prime factor in every GENERAL INDUSTRIES FRACTIONAL H.P. MOTOR.

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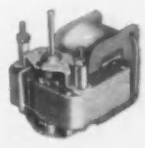
Write for complete specifications and quantity-price quotations.

MODEL E
4-pole, shaded pole AC Induction Type

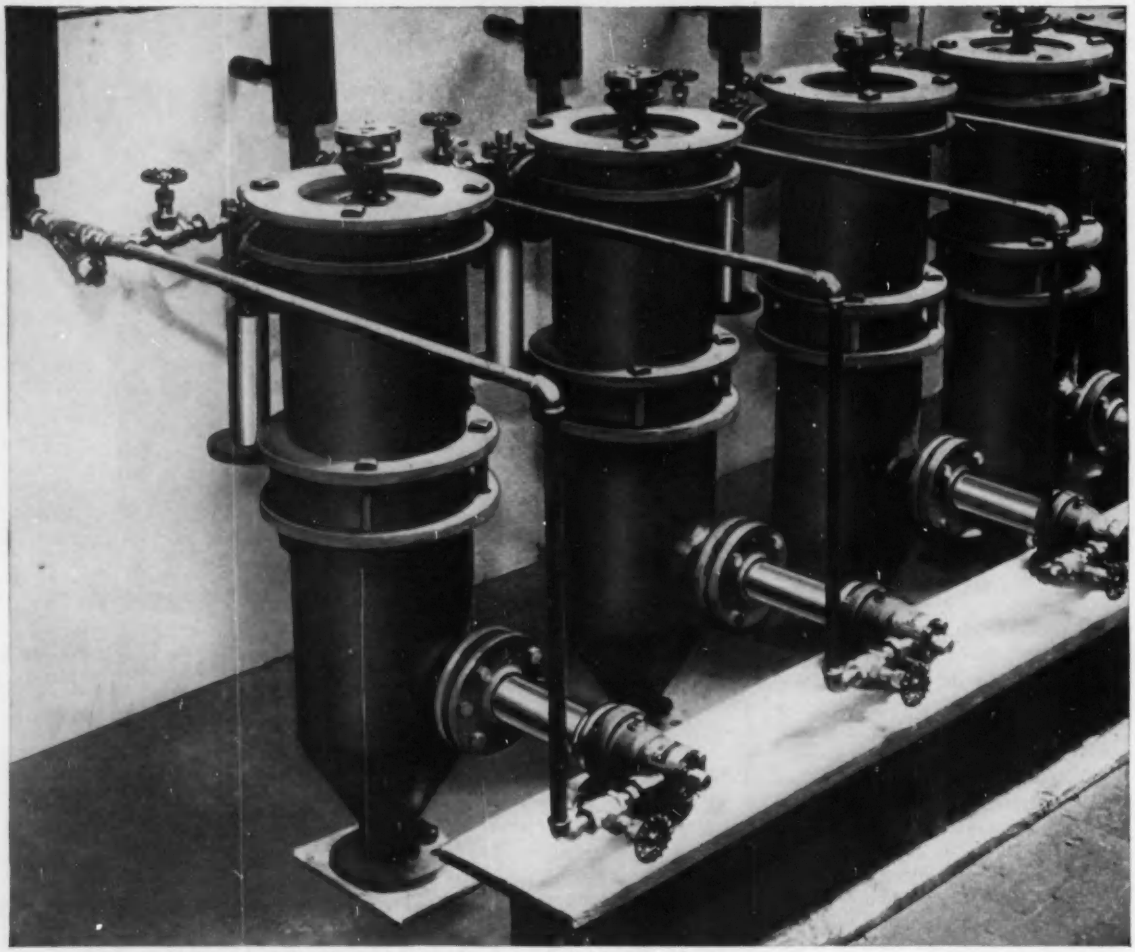
MODEL D
4-pole, 4-coil shaded pole AC Induction Type

MODEL O
2-pole Capacitor Reversible Type AC only (for 6, 12, or 24 volts)



MODEL F
2-pole, shaded pole AC Induction Type

THE GENERAL INDUSTRIES CO.
DEPARTMENT GM • ELYRIA, OHIO



Steam jet diffusers fabricated by Schutte & Koerting Company, Cornwells Heights, Pennsylvania.

TITANIUM cuts replacements 90%

These "steam jet diffusers" create a process vacuum in a large scale chemical operation. And they used to be replaced every three months.

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Investigate REM-CRU titanium for yourself whenever you find too-frequent metal failures under corrosive conditions. Remember, it is available in all sizes and grades—and in substantial quantities at the lowest prices ever, thanks to REM-CRU's expanded facilities and recent price reductions. So find out more about titanium—call in a REM-CRU engineer today.

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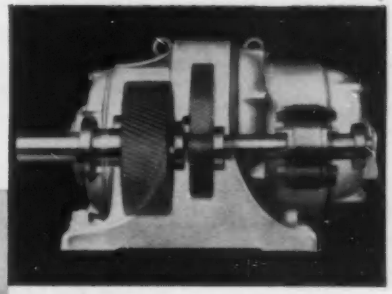
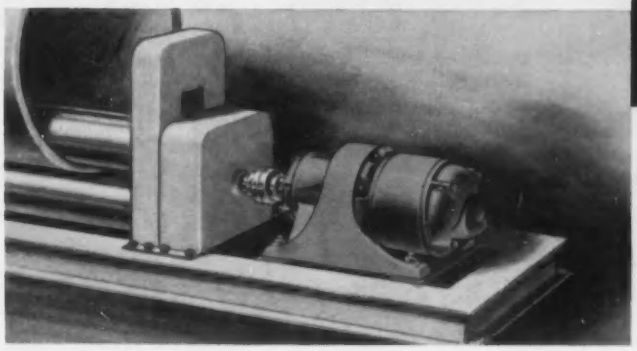
REM-CRU TITANIUM

REM-CRU TITANIUM, INC., MIDLAND, PENNSYLVANIA

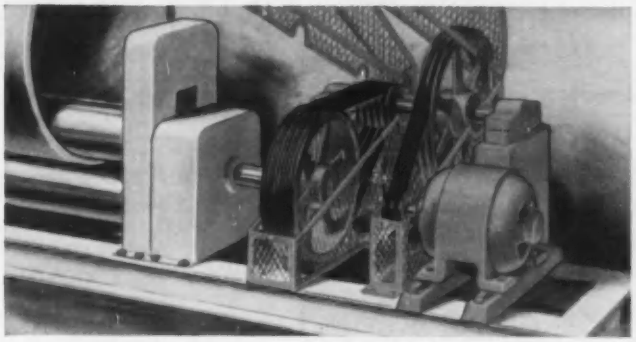
Simplify WITH SYNCROGEAR INTERNALLY GEARED POWER

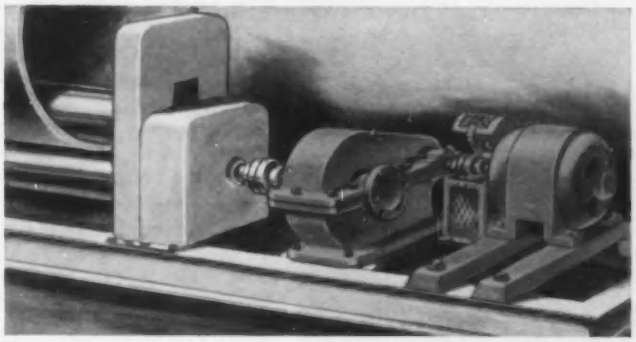




▲
U.S. SYNCROGEAR MOTOR
5 TO 10,000 RPM
⅓ TO 30 H.P.

Reject CUMBERSOME HOOKUPS





The U. S. Syncrogear is more than a motor. Its "packaged" assembly includes a high speed motor, an enclosed sealed gear-train, correctly engineered for the load, always in exact alignment, all mounted in a single case which saves space and eliminates the ungainly appearance of complicated hookups.

You don't have to calculate chain, sprocket, bearing or shaft requirements, or invest in separate mechanisms, special fabricated guards, extra pulleys and belting when you direct-connect a Syncrogear.

More and more manufacturers are using Syncrogears on their products to improve appearance and increase saleability.

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THE ORIGINAL "GEAR-WITHIN-A-GEAR" ROTARY PUMP

intended for sub-zero temperature applications. Babcock & Wilcox, Beaver Falls, Pa.

Circle 114, inside back cover

Midget Solenoid Valve—Bulletin 8314, 2 pp, describes three-way valve and provides explosionproof approvals and pressure ratings. Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.

Circle 115, inside back cover

Two-Way Solenoid Valve—Bulletin V5006, 2 pp, describes 1 in. valve, constructed to handle corrosive fluids and gases. Automatic Switch Co., 391 Lakeside Ave., Orange, N. J.

Circle 116, inside back cover

Electronic Timers—Brochure, 6 pp, describes delay, repeat, cycle, and interval timers. G. C. Wilson & Co., 1915-8 Ave., Huntington, W. Va.

Circle 117, inside back cover

Welding Fittings—Folder FB-500, 6 pp, tells types and size ranges of various seamless welding fittings and flanges which can be furnished. Babcock & Wilcox Co., Beaver Falls, Pa.

Circle 118, inside back cover

Electric Tachometers—Catalog 18-12-1102, 4 pp, describes line of panel instruments used for indicating engine speeds. Stewart-Warner Corp., 1840 W. Diversey Pkwy, Chicago 14, Ill.

Circle 119, inside back cover

V-Belts—Manual, 14 pp, covers following topics: designing new drive; double matching; installation of belts; how V-belts grip; importance of tension; drive alignment; how to clean; storage. B. F. Goodrich Co., Akron, Ohio.

Circle 120, inside back cover

Flexible Hose—Bulletin 60, 6 pp, gives information and prices on hoses and ducts. Flexaust Co., 100 Park Ave., New York 17, N. Y.

Circle 121, inside back cover

Anthropomorphic Test Dummies—Brochure, 23 pp, describes modular series of test dummies. Alderson Research Laboratories, Inc., 10 E. 38th St., New York 16, N. Y.

Circle 122, inside back cover

Shaped Alloy Wire—Bulletin T-2, 4 pp, presents detailed information on available shapes, sizes and materials,

(Continued on page 313)

and discusses several interesting applications of shaped wire. Alloy Metal Wire Div., H. K. Porter Co., Inc., Prospect Park, Pa.

Circle 123, inside back cover

Piping Design–Brochure, 12 pp, details general analytical method of piping flexibility analysis, for evaluating stresses, reactions and deflections in complex piping networks. M. W. Kellogg Co., 225 Broadway, New York, N. Y.

Circle 124, inside back cover

Plastic Products–Bulletin, 4 pp, describes line of nylon, Teflon and other non-metallics in terms of properties and characteristics. Polymer Corp. of Pennsylvania, Reading, Pa.

Circle 125, inside back cover

Explosive Valves–Catalog 5501-XV, 4 pp, illustrates and describes line of explosive valves which operate by firing a small, completely contained explosive squib. Conax Corp., 7811 Sheridan Drive, Buffalo 21, N. Y.

Circle 126, inside back cover

Miniature Ball Bearings–Catalog 1955-56-C, 4 pp. Basic dimensions and dynamic capacities for over 300 standard radial ball bearings and over 50 other standard ball bearings are illustrated and tabulated. Miniature Precision Bearings, Inc., Keene, N. H.

Circle 127, inside back cover

Tubular Rivets–Booklet, 4 pp, shows how various types of tubular rivets are applied. Special sections are devoted to dimensions and specifications. Townsend Co., New Brighton, Pa.

Circle 128, inside back cover

Electrical Fittings–Catalog 561, 4 pp, contains illustrated descriptions and price information. Buchanan Electrical Products Corp., Hillside, N. J.

Circle 129, inside back cover

Small Pumps–Booklet, 4 pp, describes line of rotary displacement and centrifugal pumps for chemical service. Eco Engineering Co., 12 New York Ave., Newark, N. J.

Circle 130, inside back cover

Glass Fiber Products–Catalog, 8 pp, describes and illustrates use of blanket insulation for thermal and acoustical treatments, along with compressed board, a resilient cushion material,

(Continued on page 315)

Cramer

RUNNING TIME METERS

Type 631E

Type 640B
Portable reset type

Type 690
Precision totalizer

Type 630E
Flush panel mounted

Type 640E
Fully enclosed, with reset wheel

widest time ranges.. variety of models

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A variety of types—reset or non-reset . . . meter mounted or portable . . . drum or dial counters—are available to meet your exact requirements, and all are driven by the precision-built, high torque Cramer synchronous motor.

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Cramer TIMING DEVICES

SPECIALISTS IN TIME CONTROL

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IN 64,000 COMBINATIONS

T-J Spacemaker CYLINDERS

OUTMODE ALL OTHERS . . . SAVE 40% SPACE!

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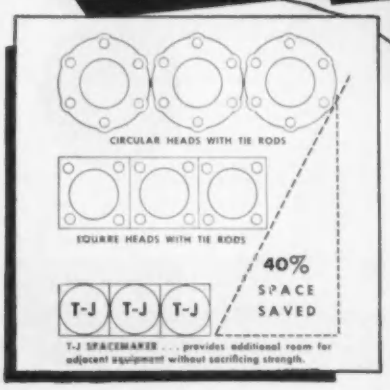
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quartz and glass micro-fibers, reinforcements for plastics, and yarns for the textile industries. L. O. F. Glass Fibers Co., 1810 Madison Ave., Toledo 1, Ohio.

Circle 131, inside back cover

Spring Design–Data sheets discuss residual stresses, stress concentration, design stress, fatigue life and the effects of elevated temperatures. Hunter Spring Co., Lansdale, Pa.

Circle 132, inside back cover

V-Belts–Data sheet, 4 pp, covers grommet V-belts, high-capacity grommet V-belts, high-capacity static conducting belts, oil-resisting V-belts and double-V belts. Included is a chart showing standard and high capacity V-belt numbers, sizes and pitch lengths. B. F. Goodrich, Akron, Ohio.

Circle 133, inside back cover

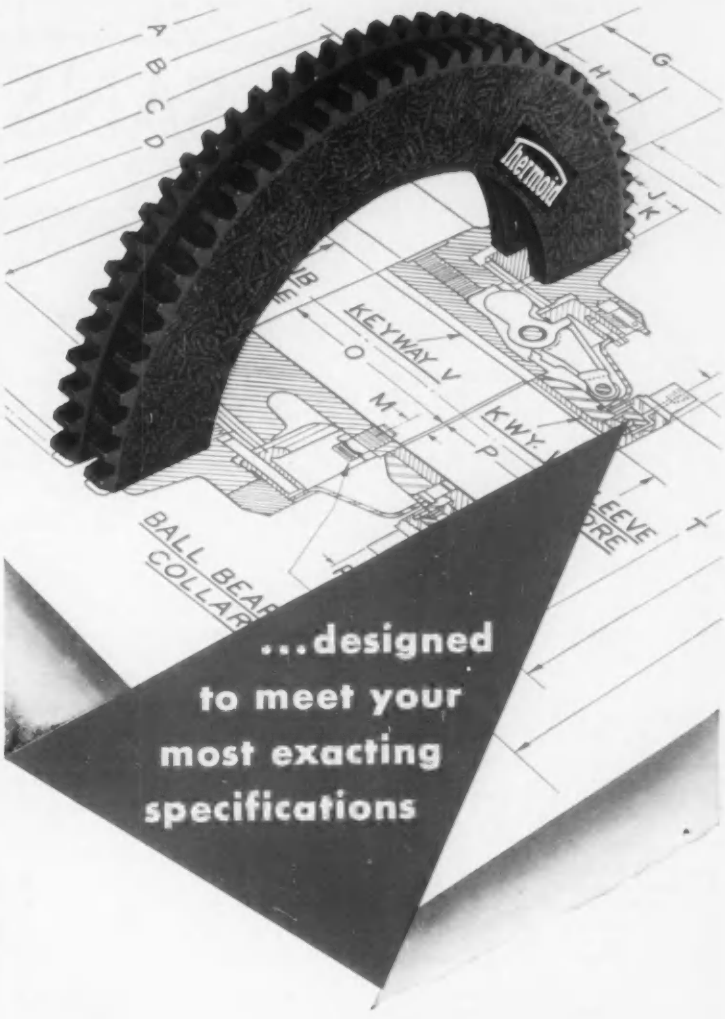
Letterhead Requests Only

Manufacturers who published following literature ask that requests for copies be made on company letterheads.

Jig, Fixture and Machine Parts–Portfolio contains 48 8½x11 in. tracing templates of all sizes of this manufacturer's strap clamp assemblies, malleable and aluminum hand knobs, speed handles, speed bar knobs, revolving clamp assemblies and swing clamp assemblies. In addition the portfolio contains an angle chart which gives formulas for finding functions of angles and a chart showing decimal equivalents of standard drill sizes. Jergens Tool Specialty Co., 712 E. 163 St., Cleveland, Ohio.

Speed Reducers–Catalog 155, 112 pp. Individual sections contain dimension and parts drawings, weights, shaft arrangements and ratings for each model reducer described within the section. All sections have index tabs at the front. A portion of the catalog is devoted to general engineering information that users will find useful on speed reducer selection and application. Winsmith, Inc., 23 Eaton St., Springville, Erie County, N. Y.

Carbon and Rubber Products–Catalogue, 32 pp, is divided into two sections, the first describing the graphite products, the second the rubber products. Henrite Products Corp., Ironton, Ohio.



Thermoid Friction Materials fit into your designs perfectly because they're custom-engineered to your exact specifications.

In Clutches manufactured by Twin Disc Clutch Co., Racine, Wisc., two Thermoid Clutch Facings, developed from superior compounds, provide smooth, positive engagement with minimum wear.

Leading manufacturers coast to coast have found it pays to specify Thermoid Friction Materials—not only for quality, but for Thermoid's *Personalized Engineering Service*. Thermoid is big enough to handle mass production demands . . . small enough to assure close liaison with your engineering staff.

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In a wide range of applications, Curtis Joints offer the designer assurance of long life and trouble-free performance — because they are quality-controlled at each step of manufacture.

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- Fewer parts, simpler construction
- Complete equipment for government tests

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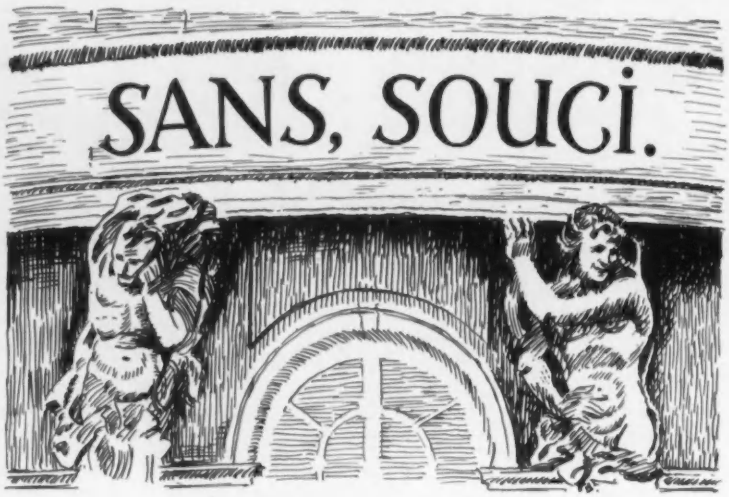

Ad Libbing by the Editor

At lunch one of my old friends, Johhy Sasso of the G. M. Basford Co., told me the story of the man who went to the hospital. The doctor told this man that immediately after the operation he would be required to sit up. The next day he would be compelled to sit in a chair. The following day he would have to walk around and the next succeeding day he would have to go home. To all of this the prospective patient asked the doctor, "Will I be allowed to lie down during the operation?"

All of this reminds me of the things we are expected to do, the things that we are allowed to do and the things that are required of us in the course of everyday life.

What we expect and what we desire are largely determined by our jobs and our responsibilities. I will always remember the conversation I had with a man who had just interviewed the salesman of a motor manufacturing company. Said my friend:

"Gee, I asked him a simple question. All that I wanted to know was information about the starting characteristics of a motor. All that I got for an answer was numbers and numbers until I was completely dizzy."

When I heard this I had to smile a little to myself. After all, it was Lord Kelvin who made that wonderful statement to the effect that we know nothing about a subject or a thing until we can measure it and express those measurements in numbers.

Presumably some of the boys whose basic job is to put things across, latch on to the idea that if they can express something in numbers it will stamp them as being tremendously well informed and smart. When a fellow gets to that state of mind, all you have to do is ask him a question and the answer will be in numbers.

What so many people fail to recognize is that numbers are the result of, or stem forth from, a basic philosophy. After Einstein had established as a result of philosophical reasoning that mass and energy were mutually interchangeable, he expressed it all in the famous Einstein equation. This was nothing more than an expression in mathematical terminology of the law that Einstein had deduced. Einstein's reasoning was not based upon his formula. To the contrary, his formula was nothing more than the mathematical expression of the fundamental principle that he had discovered. The principle came first, the formula came last.

Those who attempt to state glibly a formula or a mathematical relationship to indicate their authority on a subject will very likely delude only those who are uninformed.

However, if the other party to the conversation is smart he will quickly trip up the glib talker who is using the power of numbers to prove a point and yet has no respect for the accuracy of the numbers he employs.

Quite a few years ago I was drawn into a conference concerning a design failure. One of the members of the conference was asked why he was so

(Continued on page 320)

SHAPES

SIMPLE

OR

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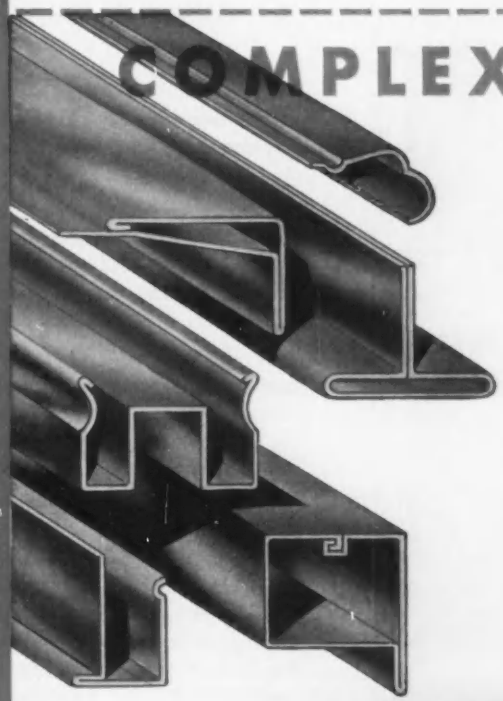

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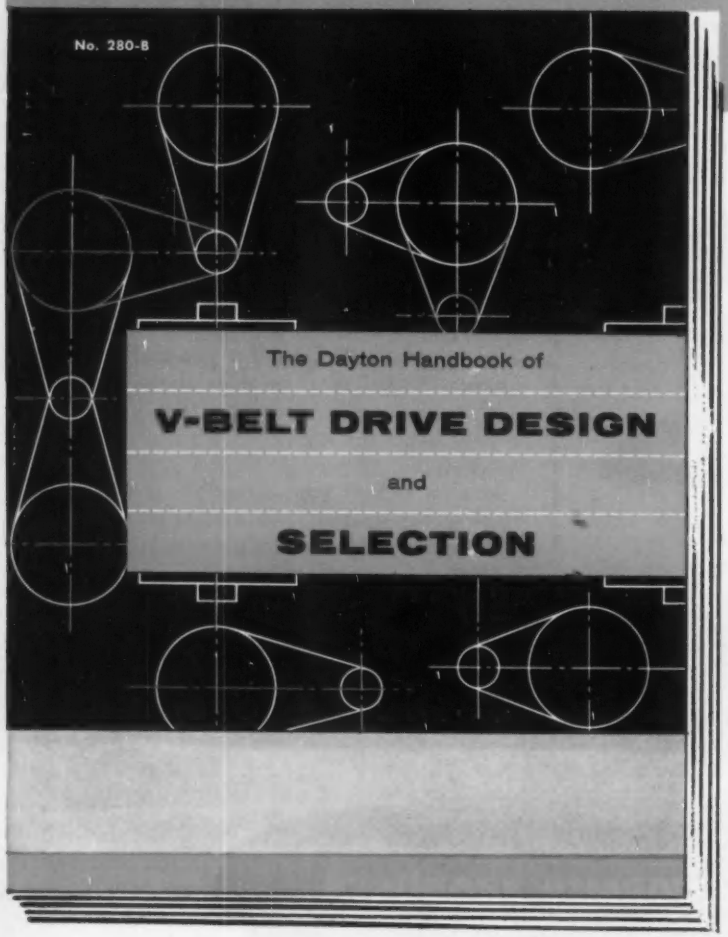
New Dayton V-Belt Drive Handbook

simplifies design problems

Now 180 page manual saves hours of research and calculation, insures complete accuracy in drive design or selection



Most comprehensive V-Belt Drive handbook in the design field.

You'll find real, usable value in every page of this remarkable collection of V-drive data. Product of over 3 years study and preparation, nothing has been omitted that might be of assistance to the engineer or designer.

Divided into seven informative sections, this new Dayton Handbook is virtually a V-Belt encyclopedia which you'll use as basic reference for all your drive information requirements.

Offering invaluable and complete data for the design of V to V drives, this new manual includes sections on speed reduction and speed-up drives with specific instructions and diagrams for unusual requirements such as V-Flat, Fixed Center, Quarter Turn and Connector Belt drives. A detailed index provides "finger-tip" availability to the myriad of V-drive material offered in each of the seven sections.

Tables, Charts and Diagrams save hours of time-consuming computation.

Listings of over a quarter million pre-engineered, standard V-Belt Drives, which meet approximately 95% of all requirements, practically eliminates the need for special designs. Easy to read Tables and Charts offer ready access to the Service Factors for various Drivers and Machines, specify the proper V-Belt Cross-Section to employ and provide data on Sheave Diameters and Basic Horsepower ratings.

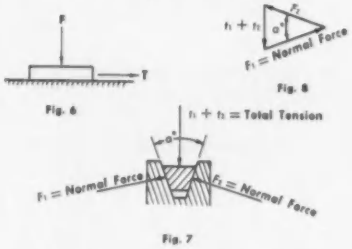
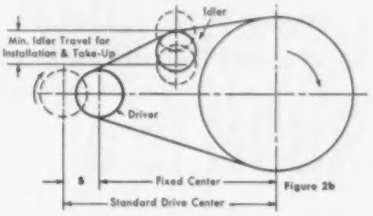


Fig. 7

Throughout the 180 fact-filled pages of this newest of V-drive design manuals are diagrams, formulas and examples covering every step in V-Belt Drive design, with a separate section devoted to designs embodying special requirements. Supplemental drive information includes such clear cut drawings as those shown above illustrating the forces acting on V-Belt Drives.

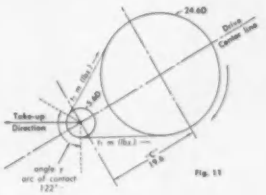
Guide to V-Belt Drive Calculation

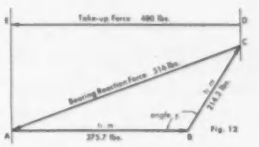
Typical of the useful information made available are the complete instructions and accompanying diagrams on how to calculate V-Belt Drives with fixed centers, (see below) as well as all other special or unusual drives.



Determination of Bearing Loads

The detailed treatment of all subjects is exemplified by the discussion of Bearing Loads (Section 6) offering formulas for determining Bearing Reaction Force created by belt tension. Case problems and solutions are discussed and shown diagramatically with clear sharp drawings similar to Figs. 11 and 12.

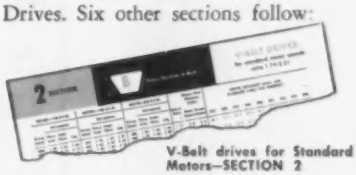




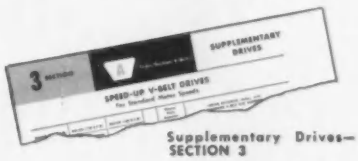
Whatever your drive design problem you'll likely find the answer in this new Dayton V-Belt Drive Handbook. Clip the coupon for your copy and attach to your company letterhead.

Seven Complete Sections Cover Every Aspect of V-Belt Use

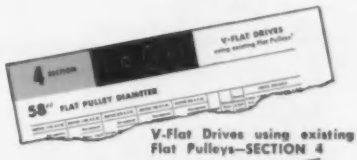
Section I introduces the subject of the development and use of V-Belt Drives. Six other sections follow:



V-Belt drives for Standard Motors—SECTION 2



Supplementary Drives—SECTION 3



V-Flat Drives using existing Flat Pulleys—SECTION 4

How to Design V-Belt Drives—SECTION 5

Special Design Information —SECTION 6

Sizes, Interchange, Installation and Maintenance — SECTION 7

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certain that the design was technically sound. His answer was very glib and emphatic. He said, "The yield strength of the material is 80,000 psi. So how could the design fail?" The chairman of the meeting obviously noted the numbers. Out of the corner of my eye I saw him write something on a slip of paper and then he called in his secretary and gave her the slip of paper. It was not until almost a half hour later that the secretary came back with another slip of paper and then the chairman turned to this engineer who had talked so glibly and authoritatively and said to him, "If I remember correctly you said that the maximum stress in this part was 15,000 psi and the yield strength of the material 80,000 psi. Is that correct?"

To this the engineer replied, "Yes, those were almost exactly the numbers that we had figured."

Then the chairman said, "According to our stress analyst the figure is not 15,000 but 22,000 psi and the yield strength is not 80,000 but 60,000."

To this the engineer replied, "Well 15,000 or 22,000—it is of the order of 15,000."

Needless to say, the engineer in this instance was taken to task and finally passed out of the picture. He had glibly spoken with authority about a subject of which he really knew little or nothing.

Whenever I hear a man holding forth with extreme glibness on any technical subject I quickly conclude that the man is talking with great speed in order to cover up vast ignorance.

Opposite of all this was demonstrated by Dr. Hirshfeld, who at one time was professor of Heat Power Engineering at Cornell University and who is the author of one of the finest books on heat power engineering ever written, namely, Hirshfeld and Barnard, "Elements of Heat Power Engineering."

Dr. Hirshfeld was invited by the Lehigh Valley Engineers Club to be the speaker upon the assigned subject, "What are we going to do when the coal runs out?"

This was in the year 1921 at a time when oil and hydroelectric power were just coming into the picture. I will never forget the opening of Dr. Hirsh-

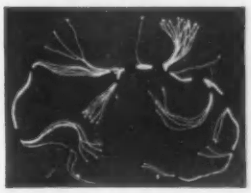
(Continued on page 324)

A-MP'S *Creative Approach* solves quality control problem for WHIRLPOOL-SEEGER

The beautiful new 1956 line of automatic clothes washers made by Whirlpool-Seeger Corporation contains the finest electrical connections easily, rapidly, and economically made with A-MP terminals.

Whirlpool-Seeger demands the very highest standard in quality control from their suppliers as well as their own plant. Whirlpool - Seeger's exclusive use of A-MP terminals on home laundry appliances results from their factual tests and experience proving that A-MP manufactures and quality-controls the ultimate in solderless terminals.

Illustrated are the various types of A-MP terminals used with automated equipment to terminate all wires in the washer. Included are FASTON, Flanged Spade, and Ring Tongue Terminals.



The terminated leads are fabricated into a harness enabling fast, positive electrical assembly of the washer.

A view of the interior of the washer showing the completed harness installed. Neat clean appearance is a further indication of the exceptional quality provided by Whirlpool-Seeger's use of A-MP terminals.

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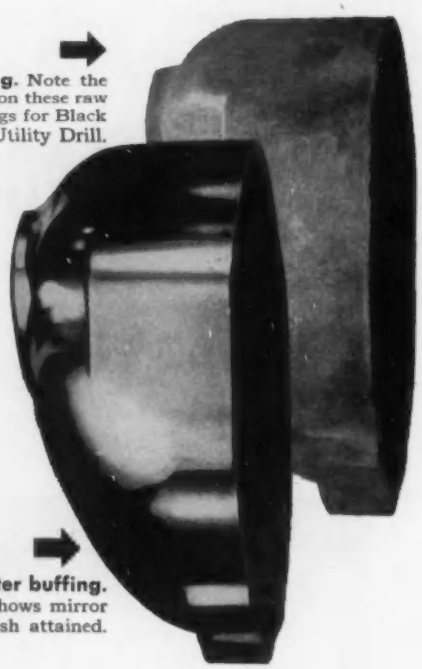

Before buffing. Note the high quality surfaces on these raw Doehler-Jarvis die castings for Black and Decker's new ¼" Utility Drill.

After buffing. Front photo shows mirror finish attained.

How Doehler-Jarvis helps *Black & Decker's* "do-it-yourself" family make merchandising history

Doehler-Jarvis die casts power tool that buff to a mirror finish in

Millions of "do-it-yourselfers" got their start with a Black and Decker power tool.

What makes people reach for a B & D tool? ...not only men, but women, too?

B & D says, "Good looks, good design, good quality, good price!"

Doehler-Jarvis die castings help Black and Decker achieve all four.

That eye-catching finish, for example. It's not chrome. It's "as-cast" aluminum, buffed to mirror brightness in *one* operation. No pre-grinding. No roughening. No grease wheeling. Not even a final buffing after assembly.

What's the secret of this quality finish?

Some people just point to a raw Doehler-Jarvis casting. "Look at that 'Hardware' surface," they say. "Not a dent. Not a blemish. Not a flow mark. It's even hard to tell where parting line and flash have been removed."

And certainly Doehler-Jarvis does give Black and Decker a casting they can work with. But you should see Black and Decker's buffing set-up. It's fully automatic, fully controlled. Air conditioned, without a speck of dust. Few concerns go as far as B & D to insure high quality buffing.

Reality lies somewhere in between

Achievements like this are to be expected

housings one operation

when a closely knit relationship develops between engineers of two companies over many years of product development.

Hardly a Black and Decker tool has not benefited in one way or another from this fruitful relationship. From it has come lighter weight, higher precision, increased strength, simplified and lower cost production, many performance improvements. And Black and Decker takes full advantage of the flexibility of die castings to provide extra sales features and aid economy.

Maybe this is the time for you to do as companies like Black and Decker, Singer, AMF, Underwood, York, and many another have done...time to initiate a profitable business and engineering relationship based on the use of Doehler-Jarvis die castings.

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feld's address to the Lehigh Valley Engineers Club meeting that night.

"Gentlemen," he said, "Your officers have assigned me a subect the title of which is, "What Will We Do When the Coal Runs Out?" Now gentlemen, I will quickly complete that address by telling you perfectly frankly that I don't care and I don't know what we will do when the coal runs out. So that finishes my assigned address. Now I will try to paint for you a picture of the various possibilities for sources of energy after our coal and oil supply runs out."

Dr. Hirshfeld then talked about many things including the possibilities of abstracting oil from oil shale, the further possibilities of oil from far deeper wells, the possibilities of hydro-electric power and various other possible sources of energy. But the biggest point of his whole address was his closing sentence which was to the effect, "Gentlemen, neither I nor anyone else in this room has any idea of what man will be doing when he is faced with the problem of no more oil and no more coal. But this I know, and in this I have abiding faith. The men of science and the men of technology will somehow or other find other sources of energy, far greater than any that we have dreamed of, which will supply this world with all the energy that it can possibly consume. I have no idea what that will be but I know that science, when faced with the problem, will come forth with a grand solution."

Often I reflect upon the tremendous possibilities of atomic energy and then I again realize how correct Dr. Hirshfeld was in the statements that he had made.

Dr. Hirshfeld could not possibly have foretold that atomic power would be harnessed less than 25 years later.

Today atomic energy is being overshadowed by a far greater development when measured in human values. The strong financial support of education and medicine by our great corporations and the foundations they created will lift the human race to far higher levels than can the bomb. The stimulation for the development of the atom bomb stemmed from fear and the desire for power. The swelling financial support of medicine and education stems from many things but without the stimuli born of religion it could not happen. —G.F.N.

New ASCO 3-Way Solenoid Valve assures MILLIONS OF TROUBLE-FREE OPERATIONS

NO EQUAL IN SIMPLICITY!

Simplicity is the secret of this remarkable, new 3-way diaphragm valve. It has *only three operating parts.* Compare this with the larger number of parts found in conventional 3-ways! That's one reason why the new ASCO valve means trouble-free operation . . . substantial savings in maintenance costs . . . reduction in down-time losses.

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Not only its construction but also its new operating principle is the essence of simplicity: solenoid piloting of two simple diaphragms.

UP TO 400 CYCLES PER MINUTE

Exceptionally large flow capacity makes rapid recycling feasible . . . cylinders fill and vent rapidly . . . valve operates up to 400 cycles per minute over millions of strokes.

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Developed for dependable control of liquids and gases, the valve can be converted from normally open to normally closed or the reverse by simple rotation of the valve bonnet.

This new valve is absolutely tight seating . . . no closely fitted parts or valve seat grinding required. Available now in ⅜" and ½" pipe sizes, both with full ⅜" orifices, it can be mounted in any position.

WRITE NOW for your copy of ASCO Bulletin 8316, or have the ASCO Engineer call.

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CIRCUIT BREAKER

Compact design of the new EQ-P type circuit breaker introduced by I-T-E now provides compact plug-in lighting panelboards. A factor in making possible this compactness was the smaller, more efficient Gibson electrical contacts developed to do the job in this tiny single-pole breaker.

In fact, the contacts are an important part of the story.

The problem: to develop small contacts that would withstand a 5,000-ampere short circuit test, maintain low temperature rise, have high interrupting rating, keep contact resistance low, and never need attention. Special Gibsiloy silver-tungsten contacts were tested and approved by I-T-E for the EQ-P breaker. These Gibsiloys were outstanding in every way.

The same 23-year Gibson experience and knowledge behind the contacts approved for the I-T-E EQ-P circuit breaker can be put to the test in solving many other electrical problems involving contacts. Consult Gibson engineers when developing new products or improving old ones. It will pay you to do so.

Write for Gibson Catalog C-520. It contains much useful technical data on electrical contacts. No obligation.

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ABSTRACTS

Dangers Ahead for the Engineering Profession

Abstracted from "Dangers Ahead for the Engineering Profession," by N. T. Veatch, Black and Veatch, Consulting Engrs., Kansas City, Mo.; *Mechanical Engineering*, Nov. 1955.

The question of proper professional conduct within the field of engineering practice is receiving a great deal of study by many of the leading engineering societies. The following subjects are believed to justify special attention from the national societies.

1 **Competitive Bidding for Professional Engagements.** Instances of competitive bidding for professional services seem to be increasing in number. There are cases where bids are actually requested as well as submitted by members of the leading engineering societies and under circumstances which indicate clearly that price is the controlling consideration.

2 **Advertising.** The use of display and sometimes self-laudatory advertising on the part of members of the profession are also becoming more prevalent. Most of these cases involve those who offer a combination of engineering service with construction or manufacturing.

3 **Engineering by Contractors and Manufacturers.** Engineers employed by contractors and manufacturers have made outstanding contributions to society and to the profession. Everyone should be grateful for this contribution. However, there are quite a few cases where a contractor is given a contract under which engineering is also furnished. The circumstances surrounding such arrangements determine whether such a plan is to the best interests of the client. Also, there is a practice among some of those engaged in the consulting field to allow contractors and manufacturers to do engineering work which they, the consultants, should do themselves and by so doing have often brought about improper and expensive design.

Competitive bidding is believed to present one of the gravest dangers to the engineering profession. Its universal adoption on the part of the engineer and the client would end any

(Continued on page 327)

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justification for engineering being considered a profession.

Competitive bidding is well established as a proper and many times a desirable practice in commercial-business transactions. It has become a real problem in engineering perhaps because the engineer is usually directly concerned with projects involving competitive bidding and the expenditure of large sums of money.

There is no reason why an engineer cannot discuss his fee with a prospective client whenever he is asked to do so. The only prohibition to his doing so is that he does not submit a fee when he knows that it will be solely controlling in the selection.

Advertising has been a ticklish subject in professional circles for many years. The general consensus seems to be that, where such services are involved, advertising should be limited to a professional card which states that the individual (or firm) is practicing a certain profession at a certain address.

From the ethical standpoint, matters get quite involved when engineering service is combined with construction.

It is conceivable that the owner may be an engineer or have regular employees who are competent to judge engineering and desire to have the project designed and constructed under a single contract. Such arrangements are, in fact, common in industrial work. Engineering organizations considered are carefully screened prior to the negotiation of a contract and finally the functions of the engineer so far as ethics is concerned are performed by the owner or his employees.

If, on the other hand, the owner is not prepared to do his own engineering and is in need of such services he must look to the profession, and the matter of ethics is most important. He cannot afford to take chances and it is with the interest of clients of this type in mind that the societies have incorporated provisions in their codes of ethics.

Two facts seem to be quite clear:

1. Indifference to code violation on the part of the profession itself is certain to be construed by the public as acceptance on the part of the engineers.

2. Any remedial action to be effective must be taken by the societies for the reason that only they are in a posi-

(Continued on page 330)

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Blowers—Variable frequency, axial fan, axial vane, and centrifugal.

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A15AB-2 50-60 cycles and 400 cycle, single winding.

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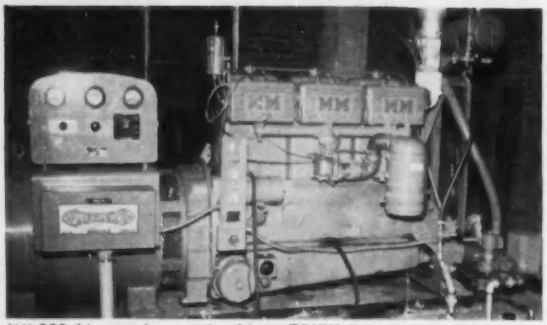
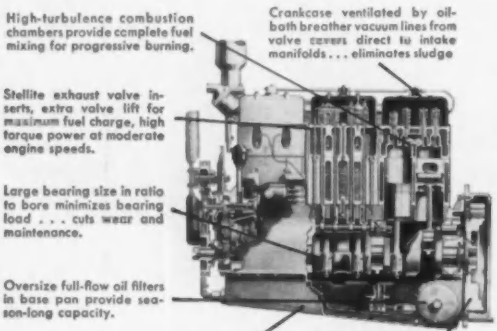


MM 800-6A natural gas engine drives a 75 KW direct-connected generator. Equipped with automatic remote control, this unattended stationary plant supplies regular or standby power.

MM 605-6A gasoline engine supplies low-cost power for this big-capacity American stationary hoist. High torque MM power units respond with steady rpm to intermittent or changing loads.

MM 403-4A gasoline engine mounted on a Warner-Swasey Gradall. Choice of gasoline, diesel, LP gas, natural gas or distillate fuel equipment offers continuous-duty MM power at lowest fuel costs.

Here's how MM MINNEAPOLIS MOLINE MODERN MACHINERY *builds* Honest HP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Crankcase ventilated by oil-bath breather vacuum lines from valve covers direct to intake manifolds . . . eliminates sludge
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Large bearing size in ratio to bore minimizes bearing load . . . cuts wear and maintenance.
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Cast base pan and wide flywheel flange give effective 360° rear main bearing support. Crankcase extends nearly 4 inches below crankshaft center line.

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4 Cylinder Carbureted Models*		6 Cylinder Carbureted Models	
MODEL 206A-4A	3⅛" x 5"	MODEL 425-6A	4¼" x 5"
MODEL 283-4A	4¼" x 5"	MODEL 605-6A	4⅝" x 6"
MODEL 403-4A	4⅝" x 6"	MODEL 800-6A	5⅛" x 6"

*Engineered for gasoline, distillate, natural or LP gas.

4 Cylinder Diesel Models		6 Cylinder Diesel Models	
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		MODEL D-605-6A	4⅝" x 6"

Honest horsepower is horsepower developed at operating speeds that are practical for heavy continuous duty. That is why Minneapolis-Moline engines are designed to develop maximum torque at around 1000 rpm and are power rated at from 1200 to 1400 rpm. Deep-pocket, high-turbulence combustion chambers for progressive fuel burning and prolonged pressure combined with large displacement and high compression ratios enable MM engines to deliver work-type power at usable speeds. Where special installations require higher rpm with rapid acceleration, MM engines can be furnished with aluminum pistons.

MM engines are stocked in various fuel models and standard equipment bundles for quick delivery. You can buy bare engines, engines with radiator, fan and power take-off, or complete enclosed units. Modification of standard units on separate production runs to meet special requirements are part of the flexible MM operation that saves you time and money.

If your design calls for long-run industrial engine power that will last the life of the equipment, we will be pleased to furnish a prompt quotation and shipping date for a pilot model built to your specifications.

MINNEAPOLIS-MOLINE
INDUSTRIAL DIVISION
MINNEAPOLIS 1, MINNESOTA

Want to pack your product into less space?

ELGIN can miniaturize your assemblies

When conserving space is vital (as it is in timing and control devices, small actuators and other electro-mechanical devices), call on Elgin's broad experience and skills for help. Miniaturization of assemblies demands special abilities and facilities in order to save space while maintaining or improving performance. We can help you redesign your assemblies and provide the highly specialized skills and facilities for assembly on a low-cost, volume basis. Call or write for a consultation at your convenience.

New Booklet Helps Solve Miniaturization Problems

Write today for "Practical Miniaturization"—free booklet explains miniaturization at Elgin and how it can help you.

ELGIN NATIONAL WATCH COMPANY
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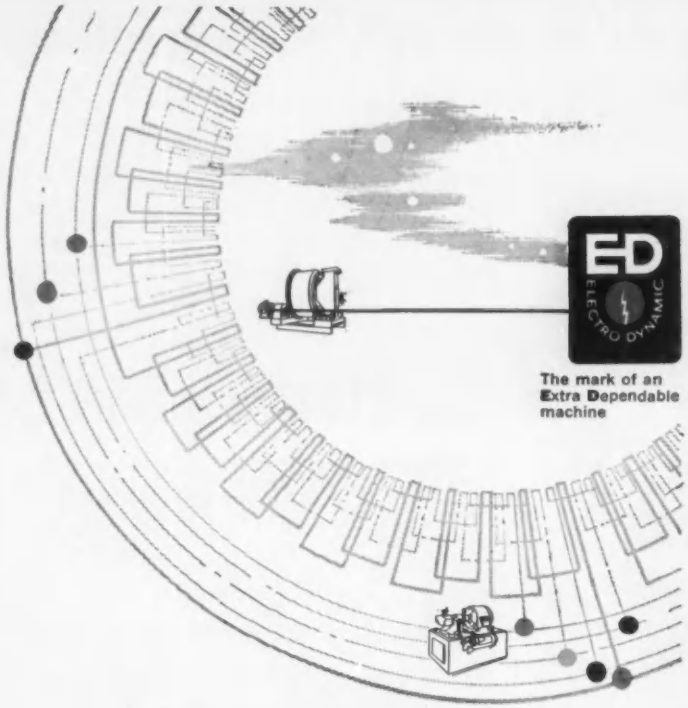
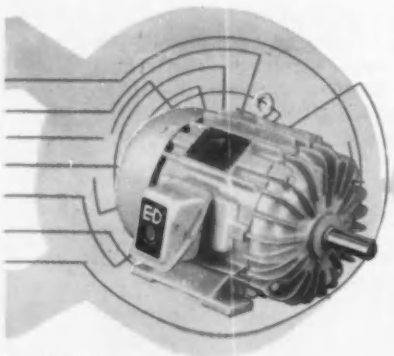


The mark of an Extra Dependable machine

a better kind of power

FOR INDUSTRIAL MACHINES



Extra starting and anti-stalling capacity: Extra cool, extra quiet operation: Achieved without sacrifice of full-load efficiency. Backed by unparalleled experience, E.D. motors are *extra dependable*—75 years in the making—yours today *at no extra cost!*

1 to 250 hp. AC and DC. N.E.M.A. standards.

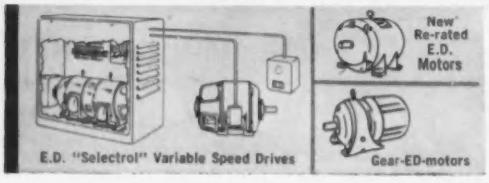
ELECTRO Extra DYNAMIC Dependable motors

GD

PRODUCT OF GENERAL DYNAMICS

NEW... Write for Brochure 100 and literature on new E.D. motors and drives.

Electro Dynamic division of General Dynamics Corporation Bayonne, New Jersey



tion to speak for the profession and to impose disciplinary action.

Our societies probably cannot stop all code violations but they can maintain discipline among their members, and when this is accomplished the profession will be in a vastly improved condition. We can bring this about but we must keep "on our toes" to do it.

Pneumatic-Hydraulic Cylinder Positioners

Abstracted from "Pneumatic-Hydraulic Cylinder Positioners," by Claude D. Young, Ch. Engr., Special Design Engrg., Foxboro Co., Foxboro, Mass.; presented before the 11th National Conference on Industrial Hydraulics, Chicago, Ill., La-Salle Hotel, Oct. 28, 1955.

A pneumatic controller for a hydraulic ram has been designed based on a force balance system whose principal advantage lies in the reduction of motion to a minimum.

Opposing forces are applied to the two legs of a bell crank. One of these forces, at a fixed distance from the bell crank pivot, is generated by air pressure in a bellows. This pressure may vary from 3 to 15 psi and its magnitude is proportional to the called for ram position. The ram moves parallel to the second leg of the bell crank and a spring-bladed ball or roller carried by the ram rides on the second leg of the bell crank. Torque applied to the bell crank increases as the ram moves the roller away from the bell crank pivot.

Any unbalance between the two torques results in motion of the bell crank which varies the position of an obstructing flapper in front of a nozzle. Pressure variations across the nozzle result in a controlled flow of oil to the ram through a relay valve. When torque on the bell crank is balanced, the obstructing flapper adjusts the pressure drop across the nozzle so that oil is blocked off from either side of the ram. Note that the motion of the flapper is of the magnitude of 0.0006 in. for relay output from 3 to 15 psi.

In an industrial model many refinements of detail design are possible. Flexure strips eliminate play in the pivots. A stroke adjustment permits control for varying ram strokes.

An air-operated hydraulic valve has been designed specifically for this application. A pneumatic cylinder re-

(Continued on page 332)

"IDEAS
in the making with C I B A Plastics"

NEW "BONDMASTER®" . . .
HIGH-STRENGTH ADHESIVE . . .
Is Based On CIBA ARALDITE EPOXY

This new adhesive which should interest anyone concerned with the bonding of metal-to-metal or other rigid materials such as glass, plastics, reinforced laminates, etc., has been developed by the Rubber and Asbestos Corp. The name? Bondmaster M620 and here's the story . . .

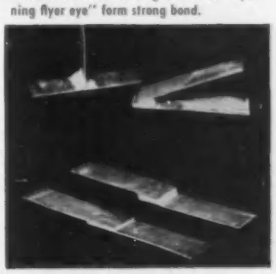
Formulation: NO MIXING . . . It's a single-component formulation you can use right out of the can . . . eliminates measuring, weighing and mixing time.

Application: NEW CONSISTENCY . . . Due to a thixotropic additive that gives BONDMASTER M620 a smooth buttery consistency it spreads easily, will not flow during curing, maintains the glue line laid down before curing. Good for "poor fit" and similar void-filling applications. No dripping or running . . . eliminates "post-cleaning" costs.

Results: HIGH STRENGTH . . . After your choice from a wide range of practical curing cycles you have a bond with the high strength and other physical characteristics you've learned to expect from the Ciba ARALDITE Epoxy which is the base for this new adhesive.

Adhesive spreads easily . . . right out of the can . . . eliminates weighing and mixing.

"Heanium" ceramic ring and steel "spinning flyer eye" form strong bond.


Allows vertical or angular assemblies to retain their original position.

C I B A
ARALDITE® Epoxies

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627 Greenwich St., New York 14, N. Y.
Please send me information on
☐ BONDMASTER, M620
☐ Also, data on CIBA Epoxy Resins
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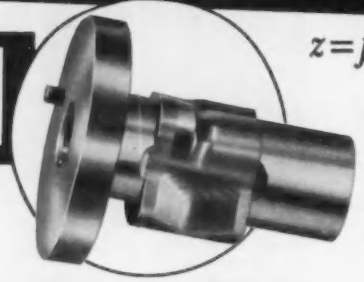
COMPANY TITLE
ADDRESS

3 Reasons for Solving Your Next Control Problem With a 3 DIMENSIONAL CAMS

$z = f(x,y)$

1

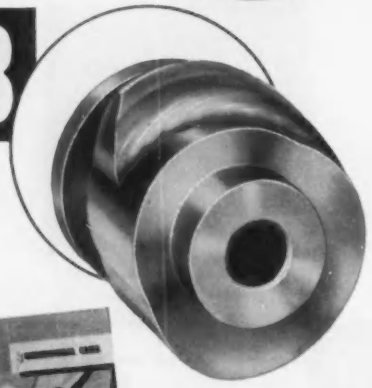


A 3 Dimensional cam can give an infinite number of exact control stations with precise interpolation between stations.

2

A 3 Dimensional cam can accomplish these superhuman "thought" functions in a minimum of space—a square inch or two.

3



A 3 Dimensional cam is a positive *mechanical* control that eliminates complicated electronics and involved maintenance.

3 Dimensional cams for automation . . . jet aircraft . . . guided missiles . . . machine tool control . . . instrumentation . . . any high precision mechanical control are now being manufactured in production quantities.

Investigate the control latitude and reliability of 3 Dimension cams by Parker—send today for literature.

THE PARKER STAMP WORKS, INC.
CAM DIVISION
FRANKLIN AVENUE • HARTFORD, CONNECTICUT

by Parker

ceives the pressure as determind by the nozzle. It furnishes a stroke proportional to the increments in pressure. Motion starts at 3 psi.

The hydraulic valve is based on the familiar "D" construction. Retained balls in a V-groove apply the force necessary to hold the two parts of the valve together. Close tolerances and good surface finish permit complete and accurate flow control through the valve.

Industrial Product Design

Abstracted from "Industrial Product Design" by Jean O. Reinecke, Reinecke and Associates, Chicago, Ill.: Engineering Institute of the University of Wisconsin, Oct. 25 and 26.

The industrial design profession was created to make products desirable and demanded by the consumer. This is at variance with a common belief that the jobs of designer and engineer are similar.

The engineer is actually concerned with the physical aspects. It is his job to make a product function and suitable for production. The industrial designer is concerned with the psychological aspects. He must create the desire of possession.

Although the industrial designer is limited by requirements of function, production, materials and cost, there is usually only one area where the job engineer and industrial designer really overlap. This is the area of human engineering, or science of determining the average distance over which a person, his arms, eyes and so forth can operate, the capabilities and limitations of the human being. It is the no-squat, no-stoop, no-squint science.

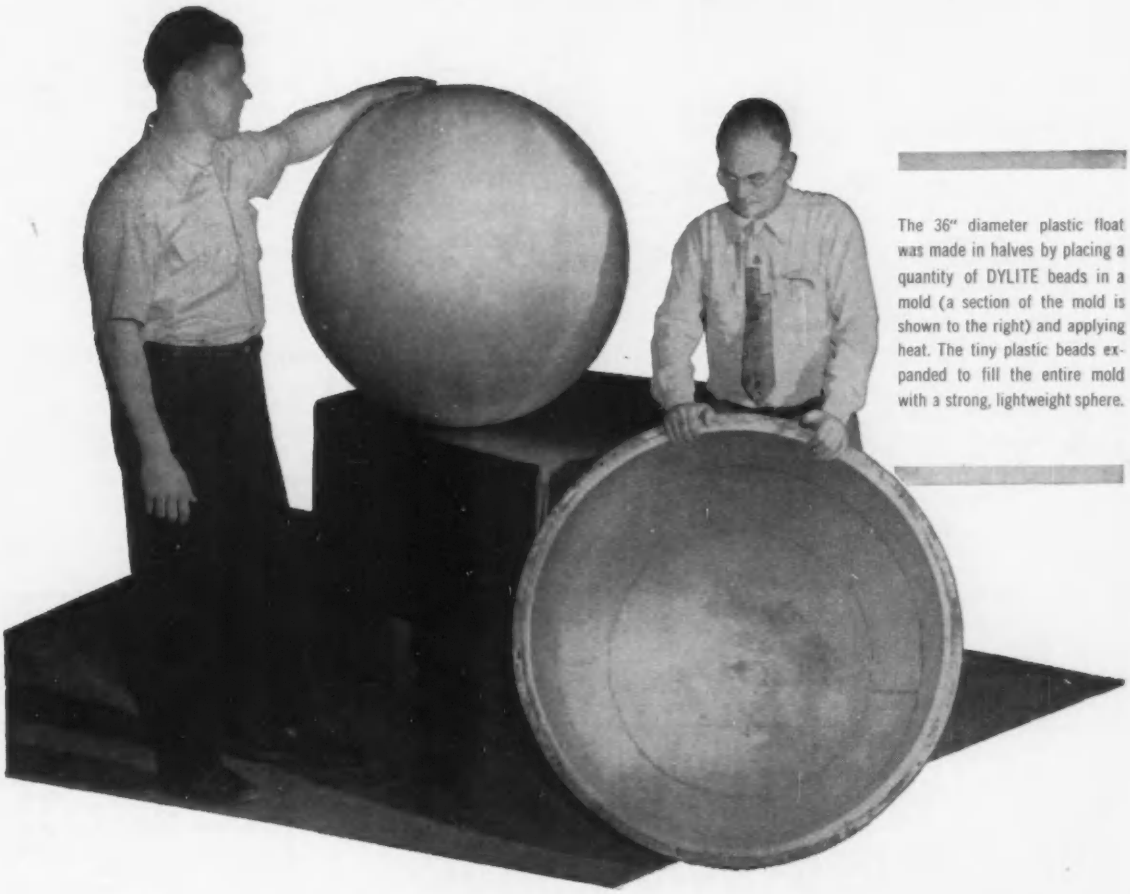
The industrial designer's interest is simply that of the user; his comfort, his degree of fatigue, his ability to operate the product with the least effort, the greatest speed, the least hazard and the greatest accuracy.

One of the more fundamental jobs of the industrial designer is to give a product character or make visible its inherent qualities. A camera must be a precision instrument to operate yet some of them do not have the appearance of being precise. He attempts to make a camera look precise, a tractor look sturdy and durable, or a chair comfortable.

The industrial designer is concerned

(Continued on page 335)

Unsinkable 42-pound Dylite* plastic float supports 20 times its own weight!



The 36" diameter plastic float was made in halves by placing a quantity of DYLITE beads in a mold (a section of the mold is shown to the right) and applying heat. The tiny plastic beads expanded to fill the entire mold with a strong, lightweight sphere.

The Navy needed a tough, lightweight float to support equipment weighing over 800 pounds. Additional requirements: the float must withstand a fall into the ocean, be easy to fabricate and float indefinitely.

After careful consideration, Navy scientists chose DYLITE expandable polystyrene for the float.

DYLITE, the new foamed plastic introduced 18 months ago by Koppers, has found many unusual applications. Tests have shown this extremely lightweight material ideal as a buoyancy agent. It is strong, waterproof, resilient, easy to mold into any shape required, is virtually unsinkable and low in cost.

For more information write to the Koppers Company, Inc., Chemical Division, Dept. PE-26, Pittsburgh 19, Pennsylvania.

*Koppers Trademark

KOPPERS

KOPPERS PLASTICS

SALES OFFICES: New York · Boston · Philadelphia · Atlanta · Chicago · Detroit · Houston · Los Angeles

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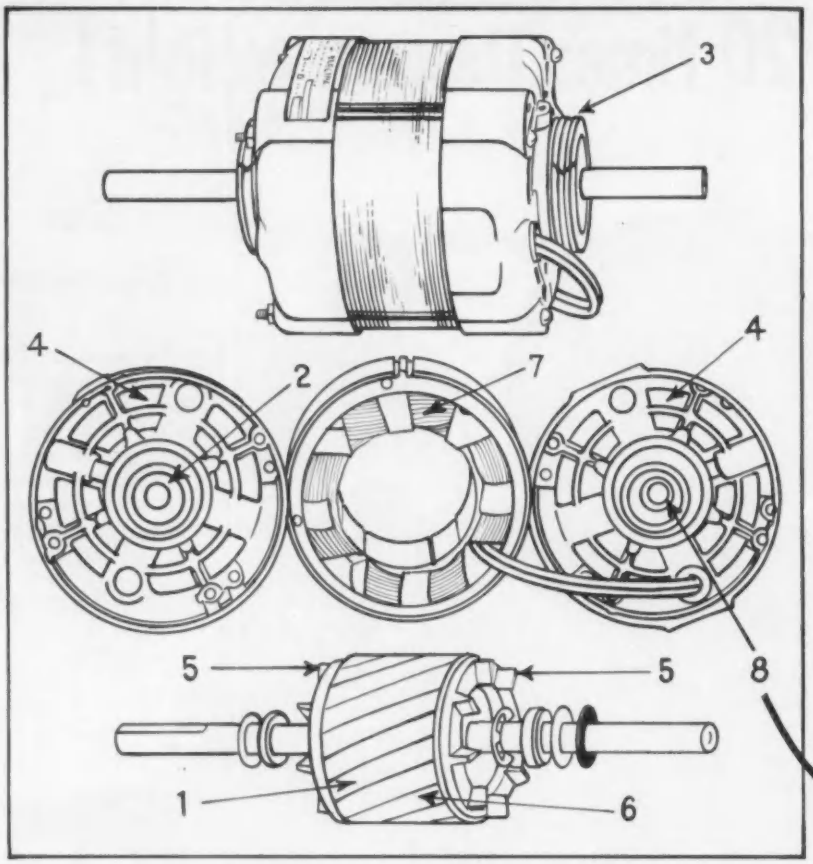
New...for ECONOMICAL drives



Quiet Operation!

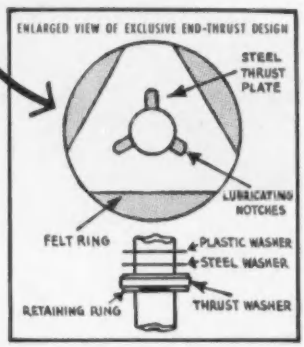
1. Full-skew rotor design. Carefully controlled maximum skew eliminates electrical and magnetic noises.
2. Two large ½-inch diameter bearings assure many years of quiet operation.
3. Special low-durometer-hardness, oil-resistant, synthetic-rubber mounting rings on all resilient mountings kill vibration noises.

Cool Operation!

4. Wide, open end-shields permit free circulation of cool air over windings.
5. Double-fan rotor design gives individual cooling to the end coils. Air enters both ends of motor, giving uniform, efficient cooling.

Highest Performance!

6. Indestructible die-cast rotor is heat-treated to increase electrical efficiency. Full-skew rotor design gives smooth, steady starting and operating torque.
7. Insulation is specially designed to withstand high humidity conditions.
8. Exclusive end-thrust design provides smooth, quiet operation and long, trouble-free motor life.



Apertures in the steel thrust plate permit lubricant from felt ring to be carried to thrust surface. Longer continuous operating life is assured.

Emerson-Electric Shaded-pole Motors

40 MHP; 1/20, 1/15, 1/12, 1/10, 1/8 HP

Wherever economy is a factor, these new Emerson-Electric Shaded-pole Motors are particularly recommended. They are noted for their quiet, cool operation and long, trouble-free life—are suited to such drives as air-conditioner fans, air circulators, unit heaters, air humidifiers, evaporative coolers, window fans, kitchen ventilators, displays.

Among many features that distinguish these new motors is Emerson-Electric's *exclusive* thrust provision which minimizes wear and reduces end play, preventing undesirable noise and variable operation, after the motor is in service. See illustration.

Get More Information

For more information on these new Shaded-pole Motors, call an Emerson Electric motor-drive specialist or write for Bulletin No. M-24. THE EMERSON ELECTRIC MFG. CO., ST. LOUIS 21, MO.

Since 1890 **Emerson-Electric** *of St. Louis*

Branches: NEW YORK 7, N. Y., 11 Park Place • CHICAGO 23, ILL., 1623 S. Pulaski Road • SYRACUSE, N. Y., 309 Oakley Drive • PHILADELPHIA (Secane), PA., 868 Quince Lane • DETROIT 7, MICH., 1375 E. Jefferson Ave. CLEVELAND 16, OHIO, 1580 Rockland Ave. • LOS ANGELES 42, CALIF., 5415 York Blvd. • DAVENPORT, IOWA, 617 Brady St. • CINCINNATI 11, OHIO, 2917 Ratterman Ave.

with the psychological. He is preoccupied with **man.** He is the liaison between the consumer and the manufacturer. Motivation rather than construction is his primary area. We all have certain predictable and known inherent or native responses. Our conditioned responses are as different in each individual as our fingerprints. Our environment, education and external influences, from the moment we are born, in some way affect the manner in which we judge a potential purchase. However, it is the industrial designer's job to determine or learn the average attitude of the public as a whole at a given time.

It is difficult to overemphasize the effect, good or bad, which the designer can have upon a corporation. In the past there was so little good design that an outstanding design often increased sales by hundreds or even thousands of per cent. Today good design is commonplace and superior design does not always result in such amazing figures. However, the difference between success and failure can lie within a 10 per cent plus or minus figure.

Automation

Abstracted from "Automation—It's Development in Metalworking," by Anderson Ashburn, Special Projects Editor, *American Machinist; Mechanical Engineering,* Nov. 1955.

By "automation," do we mean a word that has recently caught the popular fancy, or do we look beyond the word to mean the automatic handling of work in process, or do we look beyond the handling and refer to the automatic control of work in process? Or do we mean, as some have claimed, something beyond all this—a "second industrial revolution"?

A broad look at these developments over a period of years indicates that this is not a second industrial revolution, not a revolution at all, but a logical step in the evolving science of production methods.

Since 1880 we have seen a steady spread of the automatic approach. We have but to look around to see that there is a high degree of automation in the reduction of ore, the refining of oil, the production of chemicals, the processing of food, the making of cigarettes—in fact, in almost every form

(Continued on page 338)

poor paint adhesion?
If poor paint adhesion is your problem, chances are you'll find the solution in the Turcoat Phosphating Manual. This booklet describes the complete Turcoat line, tells the full story of phosphating and includes a valuable "Phosphating Reference Chart," which quickly gives the answer to any paint adhesion problem.
If you are interested in permanent paint adhesion, write today for the Turcoat Manual. There is no cost or obligation.
FREE MANUAL
shows how phosphating will solve your problems!
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You will be assured of a permanent paint seal, simply by using Turcoat as a bond for organic finishing.
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Please send me a copy of the Turcoat Manual without cost or obligation.
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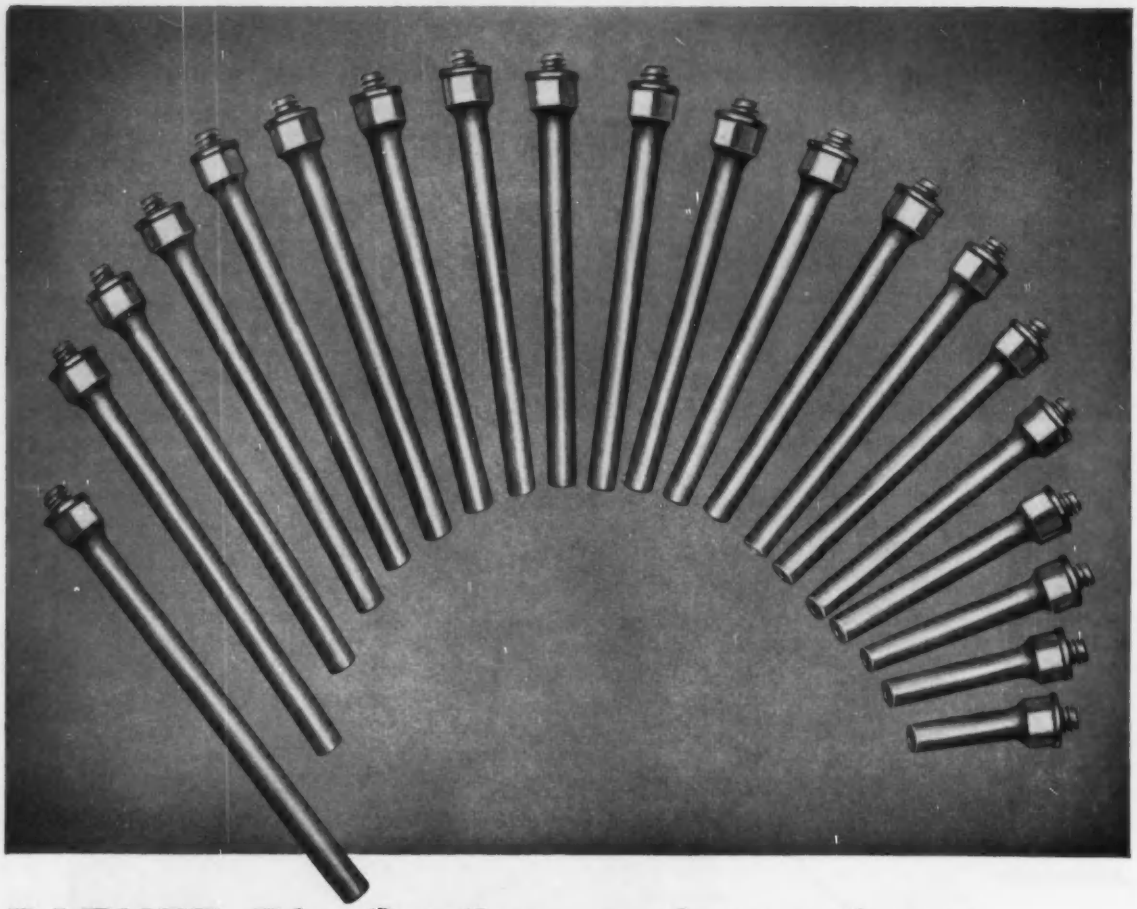

PARKER Die Casting produces these 20 Different Lengths In ONE 4-CAVITY DIE

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SALES ENGINEERS

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GIRARD, Penna.
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Girard L. Palmer • Belden Hill Road

SYRACUSE, N. Y.
J. C. Palmer • 712 State Tower Bldg.

BELLEFONTE, Penna.
Warren G. Olson • 420 East Linn Street

Lower-cost die castings are the result of the die designer's skill, experience and creative imagination. The die castings shown above are a good example. This part was required in 20 different lengths, each threaded on one end and countersunk on the other. The cost of producing multiple cavity dies for these 20 pieces would have been prohibitive. Parker solved the problem by designing one four-cavity die with removable cores of varying lengths. Just think of the savings!

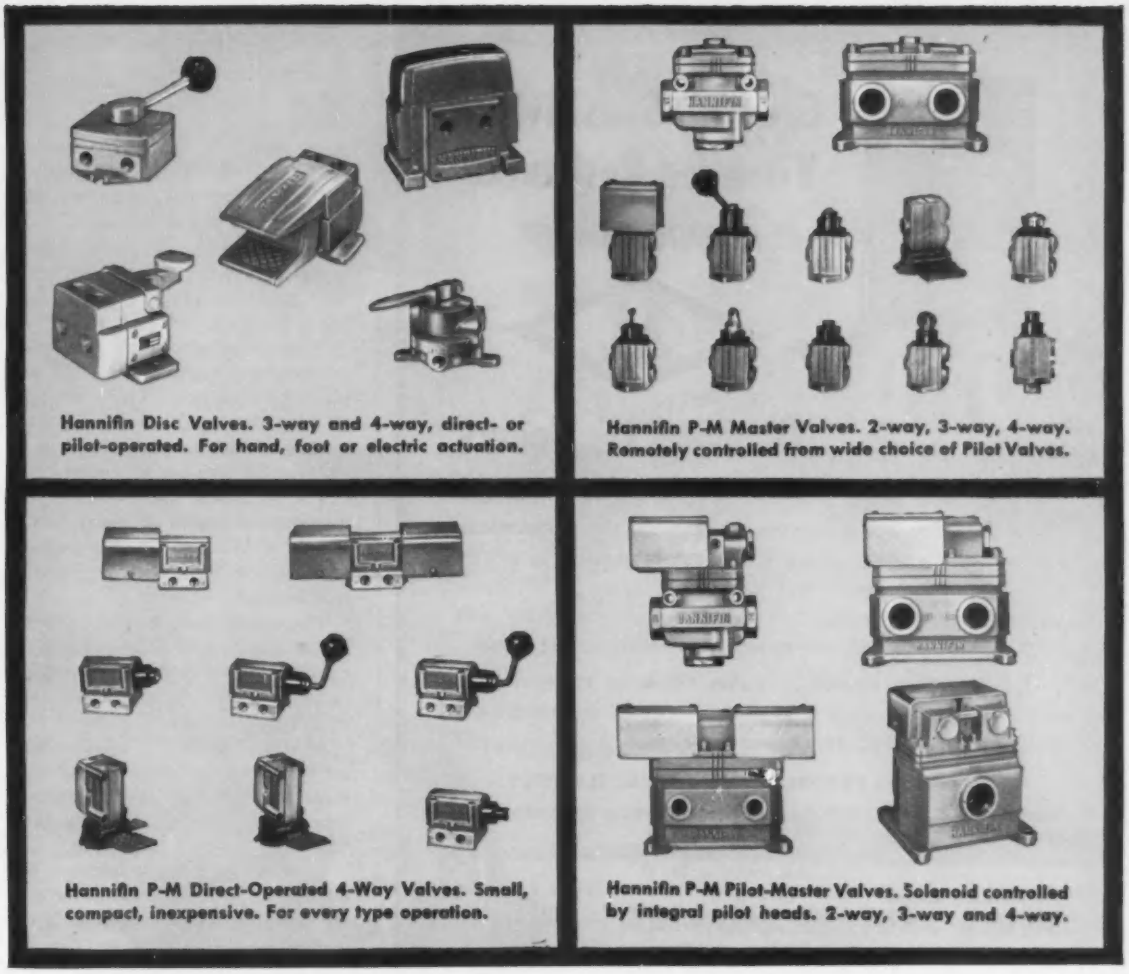
This creative skill in die design is just another example of Parker's most important product: Proving That Die Casting Cuts Component Parts Costs.

In like manner, Parker may be able to save you money on your parts. Just call the nearest Parker sales engineer listed here or write the factory direct.

Parker White Metal Company • 2153 McKinley Ave., Erie, Pennsylvania

PARKER

high pressure ALUMINUM and ZINC die castings
POWDERED METAL PARTS



Hannifin Disc Valves. 3-way and 4-way, direct- or pilot-operated. For hand, foot or electric actuation.

Hannifin P-M Master Valves. 2-way, 3-way, 4-way. Remotely controlled from wide choice of Pilot Valves.

Hannifin P-M Direct-Operated 4-Way Valves. Small, compact, inexpensive. For every type operation.

Hannifin P-M Pilot-Master Valves. Solenoid controlled by integral pilot heads. 2-way, 3-way and 4-way.

HANNIFIN has the Air Control Valves for Your Specific Applications

Hannifin has the air control valves you need for use on your production lines or on the products you manufacture, often in a choice of types.

Shown here are typical valves from the extensive and complete Hannifin line. There's a Hannifin valve for every use from the simplest to the most complicated air-operated circuit. Singly or in combination, Hannifin valves provide hand, foot, cam, pressure or solenoid operation...in almost every pipe size.

You can simplify your air control valve problems by standardizing on Hannifin. Why not discuss your requirements with your Hannifin Field Engineer?

HANNIFIN

STOCK DELIVERY ON ALL HANNIFIN VALVES — MAIL THE COUPON

☐ Have Field Engineer call at once

☐ Have Field Engineer stop by soon

☐ For the present, just send complete Hannifin Control Valves Catalog

Hannifin Corporation, 525 S. Wolf Rd., Des Plaines, Illinois

Name.....*Title*.....

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Shown Actual Size

Greater Sensitivity, Vibration Resistance *Engineered in* 'Diamond H' Relays

Continuing development of "Diamond H" miniature, hermetically sealed, aircraft type relays is constantly widening their performance range. Now, for example, in a 4 PDT relay: sensitivity to 85 mw with vibration resistance of 500 cycles at 10 "G" and 30 "G" shock resistance; vibration resistance of 55 to 2,000 cycles at 20 "G" with 50 "G" shock resistance and maximum sensitivity of 1½ watts.

Excellent contact reliability makes "Diamond H" relays preferred choice for critical jobs in vital applications ranging from guided missiles to high speed camera equipment.

TYPICAL PERFORMANCE CHARACTERISTICS

Vibration Resistance:	10-55 cycles at 1/16" double amplitude 55-500 cycles at 15 "G" 55-1,000 cycles at 15 "G" 55-2,000 cycles at 20 "G"
Temperature Range:	—55° to + 85°C. —65° to + 125°C. —65° to + 200°C.
Coils:	Resistances—1 ohm to 50,000 ohms Arrangements—single coil; two independent coils, either or both of which will operate unit
Insulation Resistance:	1,000 megohms at room temperature 100 megohms at 200°C.
Dielectric Strength:	450 to 1,250 V., RMS
Operating Time:	24 V. models 10 ms. or less; dropout less than 3ms.
Contacts:	30V., D.C.; 115V., A.C.; 2, 5, 7½ and 10A., resistive; 2 and 5A. inductive. Minimum 100,000 cycles life. Low interelectrode capacitance — less than 5 mmf. contacts to case; less than 2½ mmf. between contacts. Special Ratings: to 350 V., D.C., 400 MA., or other combinations including very low voltages and amperages or amperages to 20.
Operational Shock Resistance:	30, 40 and 50 "G" plus
Mechanical Shock Resistance:	up to 1,000 "G"
Mounting:	9 standard arrangements to meet all needs — plus ceramic plug-in socket.
Size:	1.6 cu. in.
Weight:	4 oz. or less

Call on "Diamond H" engineers to work with you in developing a variation to meet your specific requirements.

THE HART MANUFACTURING COMPANY
206 Bartholomew Avenue, Hartford, Connecticut

of manufacturing except metal working.

To find the origin of automatic machine control, we have to go back to 1801 and the Frenchman, Joseph Marie Jacquard, and his pattern loom controlled by punched-cards linked together in a chain, The Jacquard loom is still used today, in countless variations, to produce rugs, tapestries, lace, and embroidery.

Automatic control first came to the metalworking machine, however, with the cam. Perhaps the key was the turret lathe, developed in 1854, and transformed into an automatic machine in 1876 by Christopher M. Spencer.

The automatic screw machine was developed at Brown & Sharpe during the Civil War; the multiple-spindle automatic at White Sewing Machine in Cleveland.

These developments were paralleled by the development of contouring machines with tracer control working first mechanically, then electrically, and hydraulically.

Most of the effort to add flexibility to automation is toward tape or some form of numerical control. Recent tape developments have come along very fast.

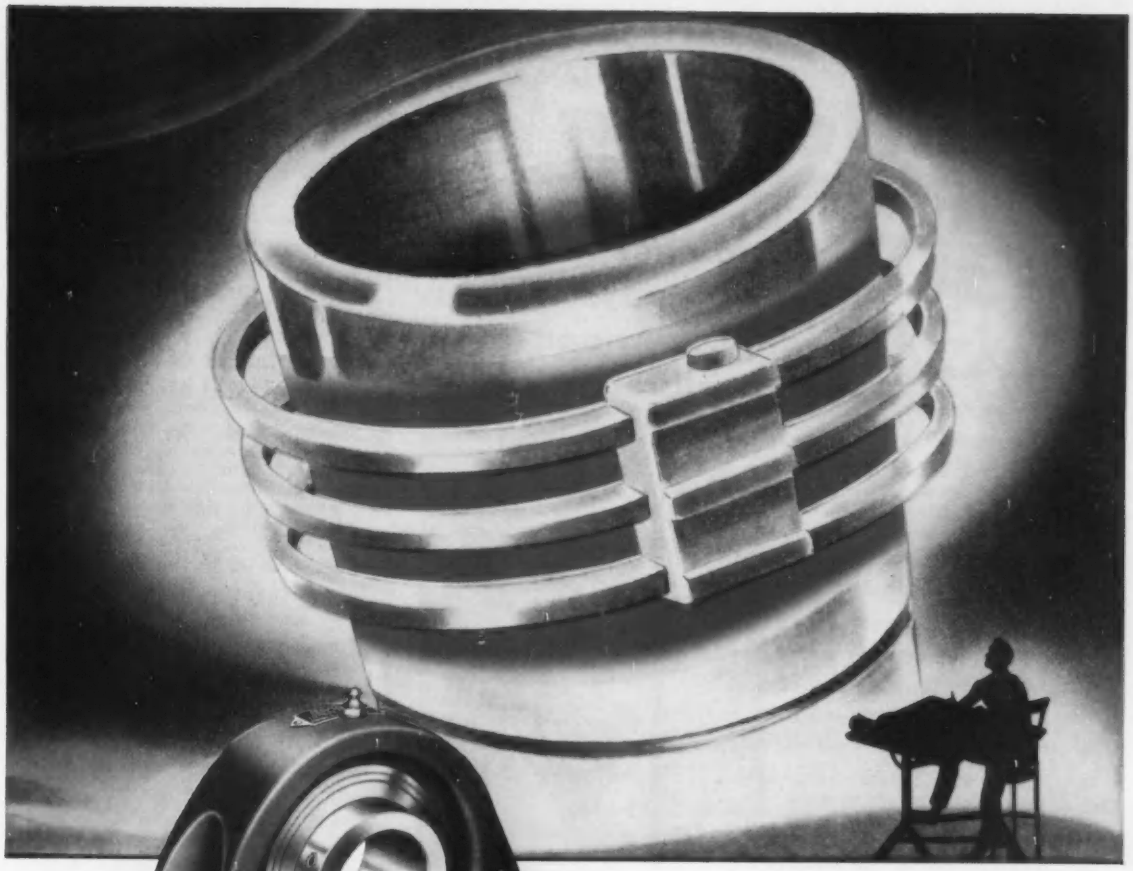
Thus we have the automated production setup, and the means for making it flexible where necessary. There remains a major problem: the dull tool. With grinders, the automatic dressing attachment and various pneumatic and electrical gaging devices provided the solution some time ago. The solution of the problem for cutting tools is more recent.

One approach is the tool-control board. A spare set of tools is preset in holders. Tests show the safe number of parts each tool can produce. The control board counts for each tool and stops the machine when one of the tools reaches its limit. The control lights indicate the tool to be replaced and the operator can replace it with the preset equivalent rather quickly.

Next step obviously is to have a toolholder that resets the tool automatically as it wears and replaces it when regrinding is needed. Several machines that accomplish this have been under development recently and the first ones are just now going into production in metalworking plants.

We are hearing a good deal about assembly now. The electrical manufac-

(Continued on page 340)



THIS ONE FEATURE *ALONE* MAKES SEALMASTER OUTSTANDING

ZONE HARDENING

SEALMASTER Ball Bearing Units provide a patented exclusive feature, **Zone Hardening,** which assures a positive race to shaft lock. **Zone Hardening** is a completely automatic heat treating process by which the inner race ring of SEALMASTER Ball Bearing Units is hardened through the ball path and adjacent section only. The extended portion of the inner race is left in its original metallurgically soft, tough state. Hardened set-screws are mounted through this soft portion of the race, permitting race-to-shaft locking with increased holding power and greater resistance to vibration and shock.

You'll want full information on the advantages of this and other SEALMASTER features—such as Self-Alignment, Locking Pin & Perimeter Dimple, Labyrinth Seal, Floating Ball Retainer, etc. Write for Bulletin 454 today.

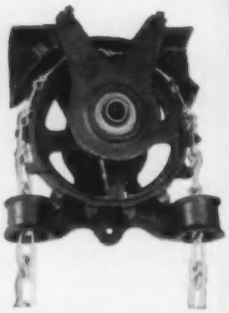
SEALMASTER BEARINGS A DIVISION OF STEPHENS-ADAMSON MFG. CO., 9 RIDGEWAY AVE., AURORA, ILLINOIS

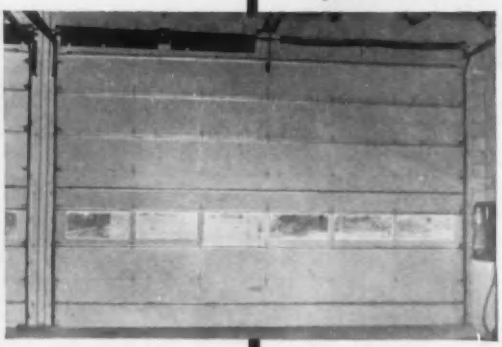
How About Malleable?

"Sturdiness and permanence pay," says a leading overhead door manufacturer.

Here is another manufacturer using malleable iron castings to improve his product. Malleable is noted for its tough strength, wear resistance, and ability to be produced in intricate shapes close to final form. Its excellent machinability, where machining is required, means trouble-free and low-cost finishing.

This versatile material has been utilized for 130 years in a wide range of applications and in every industrial field.





Call a malleable foundry and review your products with their engineers. They can often give you valuable suggestions. Or write to the Malleable Founders' Society.

Parts photos by courtesy of Quincy Mfg. Co., Tiffin, Ohio

1800 Union Commerce Building Cleveland 14, Ohio

turers have assembly machines. Other metalworking industries have, or are developing them. An assembly machine can be a very complicated looking device, but in fact is likely to be a large collection of individually simple mechanical movements with pneumatic or electronic checking devices in a closed circuit to catch and eject the defective assemblies.

Development of Cermets As Structural Materials

Abstracted from "The Development of Cermets as Structural Materials," by J. T. Norton, Prof. of Metallurgy, Mass. Institute of Technology, Cambridge, Mass.; presented at the ASME Diamond Jubilee Annual Meeting, Nov. 13-18, 1955, Chicago, Ill.

Because, at the present time, the range of substances composing the refractory component of the cermets has extended considerably beyond the metallic oxides and silicates of the conventional ceramic field, the name cermet has been questioned. A cermet may be defined, for the present discussion, as an aggregate or composite of a hard and refractory component intimately combined with a lower melting metallic component to form a dense and compact body.

The over-all picture of the present status in the cermet field, in so far as structural parts for high temperatures are concerned, may be stated somewhat as follows: In the temperature range of 1600 — 1650 F alloys are available which are quite adequate in strength and toughness; namely, the conventional "super alloys." In the 1750 — 1800 F range, alloys with good strength properties and a toughness adequate for many applications are to be found in the metal bonded titanium carbides. In the 1800 — 2200 F range, there are a number of cermet materials of adequate strength in short-time application, and a few with adequate long-time strength. However these are, without exception, too brittle to meet even the minimum specifications which a designer would set for a practical operating device. Although this result is very disappointing it does not mean that the cermet program itself has been unsuccessful. In almost every case special and important properties of the cermets have been revealed which undoubtedly will find particular application in

(Continued on page 344)

CORNING GLASS

BULLETIN FOR PRODUCT DESIGNERS

CORNING GLASS WORKS, 51-2 Crystal Street, Corning, New York

Please send me the following material:

- ☐ Booklet: "Glass and You."
- ☐ Bulletin IZ-1: "Glass . . . its increasing importance in product design."
- ☐ Information on the VYCOR brand glasses.

Name_____

Title_____

Company_____

Address_____

City_____ Zone_____ State_____

How to engineer a platypus

A happy combination of purposeful practicality is the furry platypus with its webbed feet, beaver's tail, and duck's bill.

A lot of our customers, to their continuing delight and profit (we hope), have discovered that glass is sort of platypus-like in that it, too, can be made to combine many useful characteristics.

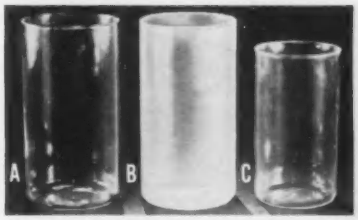
Take, for example, PYREX brand pipe. Here you see a man using a piece of it to drive a one-inch nail in a pine block. This is essentially an extra-curricular activity for glass pipe, which is more at home conveying metal-eating acids around chemical plants, but it's a way of showing just how tough glass can be when it's *made* that way.

All of which may serve to illustrate for you how we can arrange the optical, chemical, thermal, mechanical, and electrical properties of glass in different combinations to match a considerable variety of end-use requirements. In fact, we've worked up some 50,000 different formulas for glass in our years of helping customers solve specific design and processing problems.

If platypus-like glass is a novel idea to you, if you've never given glass a second thought as a highly adaptable design and construction material, we suggest your reading a pocket-size volume entitled "Glass and You." It tells in a few words and many pictures how glass contributes to profit and pleasure and we'd be delighted to send you a copy. Or, if you're more concerned with putting glass to work for you than in learning what it's doing for others, there's a slightly more technical bulletin called, "Glass—its increasing importance in product design." We'll be glad to send you either—or both.

Most remarkable glass

In 1952 Philadelphia's Franklin Institute presented the John Price Wetherill Medal to Corning's Dr. Martin E. Nordberg and Harrison P. Hood for inventing the most fabulous of glasses—VYCOR brand 96 per cent silica glasses.



Evolution of a VYCOR jar: A—formed by conventional glass blowing; B—"thirsty glass"; C—finished product.

These two scientists discovered a composition that appeared to be a combination of two distinct types of glasses. One type could be dissolved out, leaving a skeleton of 96 per cent or more of silica filled with so many millions of holes that a one-inch cube contained some 60,000 square feet of hole surface.

This new child of research was dubbed "thirsty glass" because, just sitting around, it absorbed moisture right out of the air. But our researchers were on the trail of something even more exciting. They heated their "thirsty glass" and it shrank to two-thirds its original size. The millions of little holes vanished and left a vacuum-tight glass that looked like any other—except that you could take this new glass white-hot from a blazing furnace and plunge it into ice water without the slightest injury. It was a glass as ideal as fused quartz, but different since it could be melted, mass produced, and worked in its original state like ordinary glass.

If you'd like to know more, just check the coupon above.

Ribbon glass by the yard

Here's a glass that's a thousandth of an inch thin and in small widths it's flexible as—well, a ribbon. You can twist it, roll it, wrap it around your arm without cracking it. It comes in any length you want—inches, yards, miles.

Actually ribbon glass isn't a single glass. We can make it of several different compositions according to what you need it for. Originally we developed it to take the place of mica in electronic capacitors of which there are several in your radio and TV sets and in any other piece of electronic equipment you can name. As mica is formed in layers, it is subject to cleavage in the plane parallel to lamination; ribbon glass being homogenous is easily workable. This is just one advantage of this glass in capacitors.

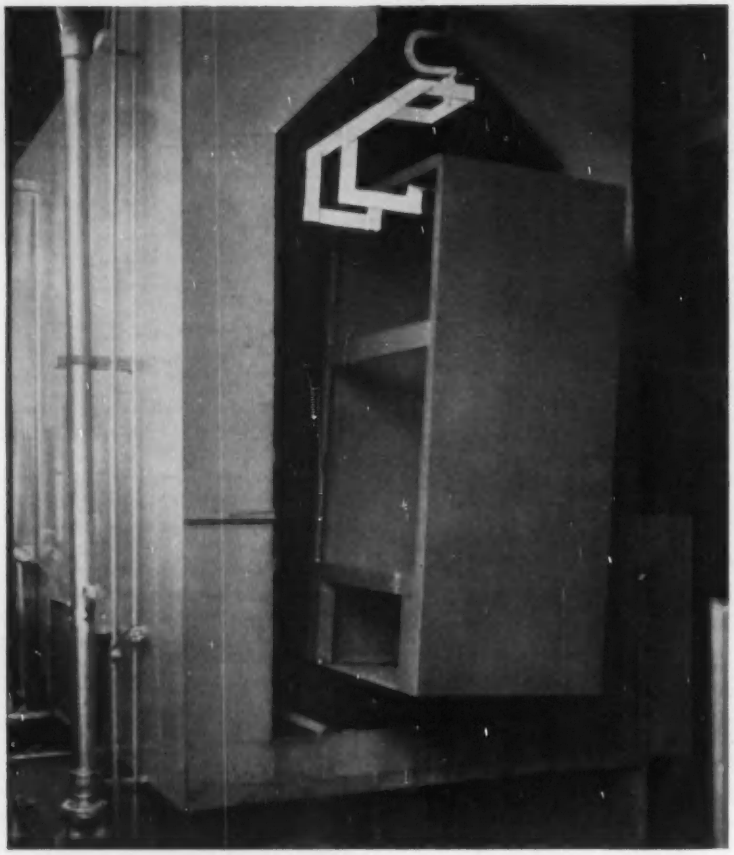
Medical scientists have found a quite different use for ribbon glass—as microscope slide covers. These are the wafer-like pieces of glass that are used to cover blood smears and the like for examination under the microscope. In this case ribbon glass can be made clearer, flatter and more free of bubbles and striae than previously made glasses.

Seems as if this unique stuff should be good for a *lot* of things, but *what* (other than electrical and laboratorial) probably lies in the laps of imaginative designers. Would you like us to send you a little strip to play with? *Customer* ideas and problems really bring out the best in glass. So, even if what's on your mind seems unrelated to any item this page discusses, glass may still be its fulfillment. We'd like to hear from you.

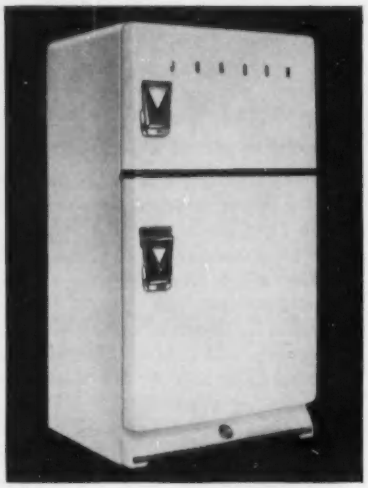
CORNING GLASS WORKS

CORNING, N. Y.

Corning means research in Glass



PART OF 5-STAGE GRANODIZING LINE at the Jordon plant. The Granodizing chemicals are sprayed onto the bodies from nozzles arranged to secure the most effective coverage of the steel.



TYPICAL OF THE FINE FINISH on Jordon equipment is that on the Model DU-21 "Duplex" Combination refrigerator-freezer.

GRANODINE® COATING INHIBITS RUST — BONDS FINISH ON FOOD FREEZERS

Phosphate coating forms a positive barrier against rust, provides a perfect bond for the priming coat and finish

To protect its products from rusting, and to assure a uniformly high quality finish, Jordon Refrigerator Company, pioneer in both the domestic and commercial refrigeration and freezer industries, Granodizes with Granodine. This process forms a substantial coating of minute, uniform crystals of an insoluble, nonmetallic, nonconductive character on the steel. The coating not only provides a constant barrier against rust, but also affords a positive means of anchoring the paint finish to the metal. Granodizing with Granodine offers another advantage, too — it prevents the spread of rust when the finish is accidentally chipped or scratched.

Still another advantage to the user of this process is offered by ACP. Its Engineering Department will help in the development of the process and process equipment. Its Service Department will make periodic inspection of the process in operation and the equipment. And its Quality Control Laboratories will run tests of finished coupons. All are free of charge — added services that keep the Granodizing process working effectively.

Write us for complete information about Granodizing with Granodine

AMERICAN CHEMICAL PAINT COMPANY, Ambler 17, Pa.

DETROIT, MICHIGAN NILES, CALIFORNIA WINDSOR, ONTARIO

CHEMICALS ACP PROCESSES

Bundy simplifies oiler-tube design, cuts fabrication time, trims costs

Another example showing how Bundy engineers help solve customers' design headaches

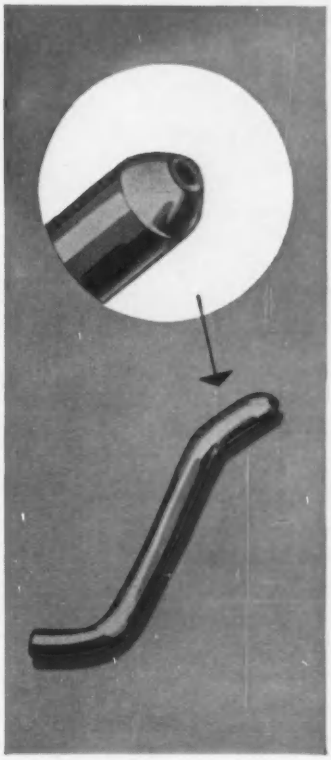
Naturally, doing everything we can to meet our customers' design specifications is a Bundy *must*. But sometimes our engineers—with their years of problem-solving experience—see ways in which original specifications can be improved. These improvements usually result in substantial savings to the customer, as in the example shown at right.

Doing just a little more than the job requires is an old habit with us here at Bundy. That's why you'll find it so rewarding to deal with us at the design stage of a new product.

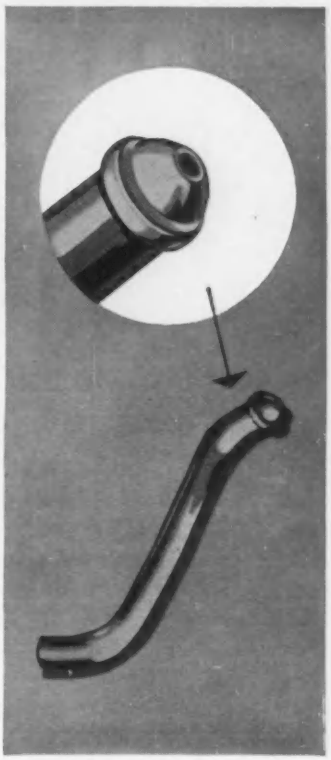
Why not profit from an unbeatable combination: expert Bundy engineering services plus the priceless extra of Bundyweld Tubing—the only tubing double-walled from a single metal strip, copper-bonded through 360 degrees of double-walled contact. Bundyweld is leakproof; thinner-walled yet stronger; has high thermal conductivity; has high bursting strength. The safety standard of the refrigeration industry, Bundyweld *is used in 95% of today's cars, in an average of 20 applications each.*

Let Bundy help you with your tubing design problem. Call, write, or wire us today.

BUNDY TUBING COMPANY
DETROIT 14, MICHIGAN



Problem: This 3/16" O.D. timing-gear oiler tube, shown above, required a tapered end for a nozzle effect. As specified by the customer, it required numerous swaging operations. Bundy engineers, always on the lookout for new ways to shave costs, hit upon the ingenious solution shown at right. With the customer's consent, original specifications were changed.



Solution: First, Bundy added upset to nozzle tip (see above). As a result, nozzle-forming operations were cut in half. But Bundy innovations didn't stop here; next, two hand-bending operations were incorporated into one automatic press operation. The over-all result: impressive fabrication savings to the customer, with no compromise in tubing function.

Bundyweld starts as a single strip of copper-coated steel. Then it's

. . . continuously rolled twice around laterally into a tube of uniform thickness and passed

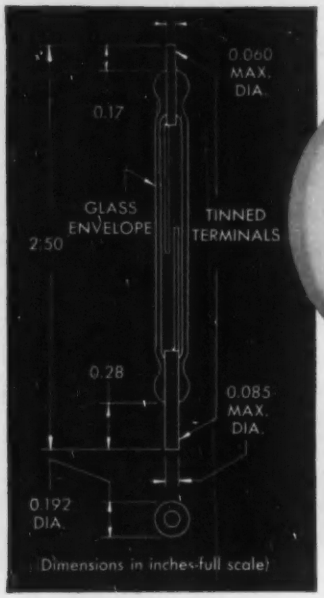
through a furnace. Copper coating fuses with steel. Result . . .

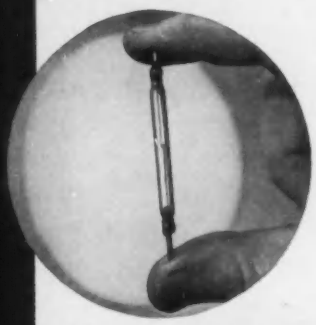
Bundyweld, double-walled and brazed through 360° of wall contact

NOTE the exclusive Bundy-developed beveled edges, which afford a smoother joint, absence of bead, and less chance for any eakage.

BUNDYWELD TUBING®

DOUBLE-WALLED FROM A SINGLE STRIP





the mighty little glaswitch*

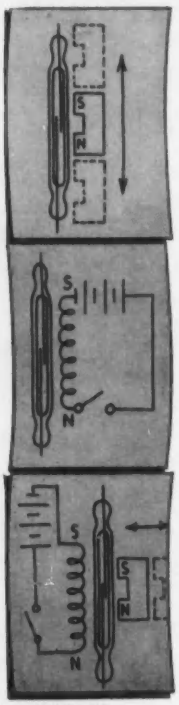
LIGHTNING RESPONSE . . . SEALED IN GLASS

The magnetically actuated reeds in this tiny Revere GLASWITCH make contact in just 1 millisecond . . . at rates up to 400 cycles per second. Hermetically sealed in an inert, dry atmosphere, with lightning fast snap action, both shelf and contact life are extremely long. Smaller than a cigarette, the GLASWITCH can be located anywhere . . . in any position . . . even in explosive atmospheres . . . individually or in multiples for multi-contact use.

Whenever you need faster, more positive response . . . where extreme sensitivity is a must . . . where light weight is important . . . investigate the Revere GLASWITCH. Write today for complete specifications and suggested uses.

CHARACTERISTICS:

Type—Single pole single throw—normally open—snap action
Enclosure—Hermetically sealed glass tube containing inert dry atmosphere
Operating Time—1 millisecond
Operating Rate—Up to 400 cycles per second
Contact Surfaces—Electroplated Rhodium
Contact Resistance (measured terminal-to-terminal)
Closed Circuit—0.050 ohms maximum
Open Circuit—500,000 megohms minimum
Contact Ratings
D.C. Loads at 28 volts
0.5 amps resistive
0.5 amps inductive (L/R—0.026)
A.C. Loads at 115 volts, 60 cycles
10 watt lamp load
Ambient Temperature Range— —85°F to +500°F



METHODS OF ACTUATION:

A moving permanent magnet or controlled external electromagnetic field are all you need . . . and the sky's the limit on imagination!

* Trademark

Revere CORPORATION OF AMERICA

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which cermets will outperform any other competitive materials and these applications may well justify all of the effort and expense of the program. However, if one considers the specific problem of a high-temperature structural material for a practical application, as typified by the bucket for a turbojet engine, the problem has not been solved and it seems proper to ask if there is any hope of a practical solution at temperatures of 1800, 2000 and 2200 F. In the author's opinion the answer should be: at 1800 F certainly, at 2000 F probably and at 2200 F possibly.

One might ask whether there is any other material, not of the cermet type, which promises to be a serious competitor in the high-temperature field. There is such a material and it is molybdenum. Alloys of molybdenum are now in development which have high temperature properties superior to any of the current cermets. The great barrier to their direct application is their lack of oxidation resistance. The use of this material is dependent upon the finding of a suitable method of applying an oxidation-resistant coating. This is not far distant and the cermets may well lose this important race to coated molybdenum. It is not impossible that the successful coating may itself be a cermet.

Hydraulic Control Techniques For Heavy Presses

Abstracted from "Recent Trends in Hydraulic Control Techniques for Heavy Presses," by Leon Mollick, and Arthur Greensite, Loewy Construction Co., Div. of Hydropress, Inc.; presented at 11th National Hydraulics Conference, Chicago, Ill, Hotel LaSalle, Oct., 1955.

Before the advent of the Air Force Heavy Press Program, the motions of cylinders on large forging and extrusion presses were controlled by opening and closing valves. However, for press installations of up to 75,000 tons capacity, the entire control scheme had to be re-evaluated. Three main considerations governed the final control scheme:

1) Because of the heavy forces required to operate the valves, some power amplifying means must be provided, preferably with

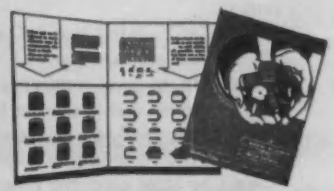
(Continued on page 346)

YOUR No. 1 SOURCE FOR COMPLETE BELLOWS ASSEMBLIES AND DEVICES

FULTON SYLPHON

BELLOWS HEADQUARTERS, U.S.A.

You gain three important advantages when you consult Fulton Sylphon, originators of the metal bellows—*1.* Over 50 years experience in bellows engineering is focused on your problem; *2.* Modern production facilities geared to good service; *3.* Cost saving opportunities through the design and production of complete bellows assemblies.



HERE'S HELPFUL INFORMATION
This 32 page catalog covers basic bellows engineering, conversion tables, metals available and other bellows data. Use the handy coupon for your free copy.

Mr. Controls

Robertshaw-Fulton
CONTROLS COMPANY

FULTON SYLPHON DIVISION
Knoxville 1, Tennessee

( ) Please have a Bellows Engineer call me for an appointment.
( ) Send me Bellows Catalog # CP-1400

Name_____ Title_____

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looking for the right tube in

WELDED STAINLESS?

Check Standard's Complete Range of tube and pipe sizes!

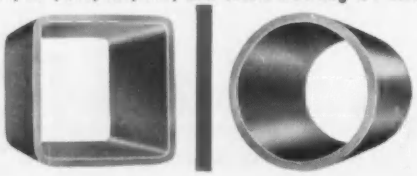
Whether it's for a pressure, mechanical, sanitary or ornamental use – Standard offers you a convenient "one source" answer to your welded Stainless Steel Tubing need.

TUBE SIZES: ¼" to 4" OD .025 to .148

PIPE SIZES: ⅛" to 2" IPS Schedule 40

TYPES: 430, 302, 304, 309, 316, 321, 347; and others including low-carbon grades.

SHAPES: Squares, Rectangles and Special Shapes



PIPE SIZES: ⅛" to 4" IPS Schedules 5 & 10

Send for Stainless Folder! Our engineers will gladly assist you in your selection of the tube best suited to your needs! Write today!

Specify Standard for

- WELDED STAINLESS TUBING AND PIPE
- WELDED CARBON STEEL MECHANICAL TUBING
- BOILER AND HEAT EXCHANGER TUBING
- EXCLUSIVE "RIGIDIZED" PATTERNS

feed back, so that the operator located remotely at any one of several alternate locations from the valves, could operate them with little effort.

2) The control system must be flexible to the extent that various interlock and safety features could be incorporated as the need arose. It must be adaptable for automatic control.
3) The system must be as safe and reliable as it is humanly possible to make it.

In the operation of extrusion presses, the extrusion speed must be controlled within close limits. Until the present time, the extrusion speed was manually controlled, and the quality of the extrusion was, to a great degree, dependent on the skill of the operator. Automatic control offers considerable advantages both as to quality of product and reduction of cycle time. Several control systems are offered.

One of the most severe requirements imposed on any forging press, is the ability to withstand, within the structure, large overturning moments which occur when full press power is exerted at off center positions. Eccentric forging conditions usually arise from a number of conditions, the most important of which are:

1) The relative configuration of the forging and the blocked billet.
2) The die design which influences the flow and temperature in the different parts of the forging.

The effect of the eccentric forging load is to induce bending stresses in the frame of the machine, and, at the same time, to cause relatively large deflections of the press structure which is referred to as "sway". The first requires excessively heavy structural design to resist failure, while the second causes various forms of die misalignment and mismatch resulting in forgings not conforming to tolerance requirements.

Protection and control may be provided by a strain gage system:

1. To protect the press continuously against an unusual or unexpected overload as well as an unsafe condition of operation, as may be caused by large eccentric forging loads, die breakage or overload of a major component.
2. To provide for additional com-

(Continued on page 348)

TDA® BRAKES

if it rotates...we can control it!

New lightweight . . .

Fabricated steel brake shoes weigh many pounds less than cast shoes. Binding or freezing up is eliminated because double web construction permits limited area fit with one piece cam rollers. Wear areas of the webs are heat treated for long life.

Unit-mounted . . .

All brake parts are mounted on the spider for compactness. Efficiency is higher and correct cam shaft alignment is assured with close coupled cam shaft and chamber bracket.*

"P" SERIES POWER BRAKES

designed for heavy-duty service

Here is a brake that gives longer, trouble-free service for trucks, trailers, and all types of industrial and road equipment. These heavy-duty "P" Series Brakes are easy to maintain in service. Simplicity of design is the keynote—with brake, air chamber, and cam shaft all mounted as a unit.

The outstanding features of the Timken-Detroit® "P" Series Brakes give increased economy and performance. Operating temperatures are lower and lining life longer because open-type spiders assure good internal ventilation and rapid cooling. Timken® "Econo-liners" are tapered to provide greatest thickness where greatest wear occurs.

A constant-lift "S" type cam assures uniform application of brake shoes for maximum control and immediate response. Brake adjustments are quick with easily accessible slack-adjusters. Once the adjustment is made, a lock automatically engages the adjusting screw to prevent its moving during service. Long wearing nylon bushings assure smooth operation with minimum maintenance.

"P" Series Power Brakes are available in a complete range of capacities and sizes to fit every operating requirement.

For additional information . . . with expert consultation, contact Timken-Detroit Brake Division. Complete specifications and information on the "P" Series Brake are available. And a staff of experienced engineers is ready to assist you with any problem you may encounter.

*"P" Series Brakes are also available with inboard chamber mounting for special applications.

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For every industrial, agricultural or automotive application where braking is required!

TDA plants at: Detroit, Michigan • Oshkosh, Wisconsin • Utica, New York Ashtabula, Kenton and Newark, Ohio • New Castle, Pennsylvania

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Accepted TDA Standard
TRADE MARK REGISTERED

PRD TRANSISTOR-
MAGNETIC SERVO AMPLIFIER

—weighs only 21 ounces
—measures 3⅞ x 2½ x 2⅝

The Type R40G7W6 is a small transistor-magnetic amplifier which is specifically designed to drive parallel connected Bu Ord MK7 and MK14 400 cps servo motors from potentiometer, synchro or resolver data. The unit has a built-in silicon transistor preamplifier and requires no stabilizer, demodulator or d.c. power supply. Truly remarkable performance is achieved with this unit as can be seen from the complete specifications.

Specifications

Maximum output: 7 watts, 57 v a.c., 400 cps
Voltage gain: with MK7 motor 2000
with MK14 motor 2400
Bandwidth: 0 - 70 cps
Zero drift: less than 3 mv ref. input
Saturation Signal: 50 mv
Input impedance: 15,000 ohms
Amb. temperature: —55° to +85°C
Stabilization: Internally provided
Power supply: 115 v ±10%, 400 cps
Hermetically sealed.
Meets MIL-E-5272, Procedure 1, Vibration Specifications.

Write for complete folder on PRD Magnetic Amplifiers

Polytechnic
RESEARCH & DEVELOPMENT CO., INC.
202 TILLARY STREET
BROOKLYN 1, NEW YORK
Telephone: ULster 2-6800

pensation whenever the eccentric moment exceeds a pre-set value.
3. To indicate visually, by means of a spot of light on the face of a cathode-ray tube, the position of the center of pressure of the forging load in reference to the centerline of the press.
4. To indicate and record the total tonnage of the press as it varies during forging.
5. To indicate and record, simultaneously, the stress in the main tie rods at the selected gage point as a function of time.

Four strain gages of the variable reluctance type are mounted on bosses which, in turn, are cemented to the columns at critical load points. The output from these gages is fed to a group of electronic circuits which combine to totalize and compare the gage output in various combinations to perform all the above functions.

As an additional safeguard, a protective feature is provided to warn against failure of any component of the strain gage system. This is done by deliberately unbalancing each bridge element by an amount corresponding to the threshold stress setting. This is done in about a ½ sec interval while the press is in the prefill position. If the system is operating normally, forging is allowed to proceed as the controls enter the "press" position. If not, the system is de-energized, giving an indication of where the trouble is by means of a series of lights on the panel, and the press returns to the "open" position.

Management Viewed
By an Engineer

Abstracted from "Management Viewed by an Engineer," by R. W. Johnson, Electronics Div., Ralph M. Parsons Co., Pasadena, Calif., *Advanced Management*, Oct. 1955.

The experienced engineer, who is the most in demand today, has usually seen many organizations, good, tolerable and bad; this is part of his normal experience. He looks carefully at the organization of a company he is about to join, and if he is the discerning sort he may become acutely conscious or even super-critical of some of the following.

Some top management men are either too scientific to be good business

(Continued on page 352)

amazing NEW
WORLD BESTOS
FRICTION MATERIALS

stop brake fade and glaze . . . assure constant friction and longer life of trouble-free service.

Brake fade, glaze, short lining life and excessive wear mean costly brake maintenance and production losses that affect the service record of your product.

World Bestos, specializing for more than 30 years in the manufacture of friction materials, supplies blocks, linings and segments engineered to solve your brake problems . . . to give your brakes a longer life of dependable, trouble-free service.

Proven friction materials for brakes on cranes, drilling rigs, hoists, drag lines, large forming presses, elevators or any type of industrial application. Also linings for automatic transmissions, torque converters and automatic clutches.

For prices and delivery information send prints or specifications to WORLD BESTOS, Industrial Products Section, New Castle, Ind. Engineering and development service is available. Write for free folder.

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Firestone
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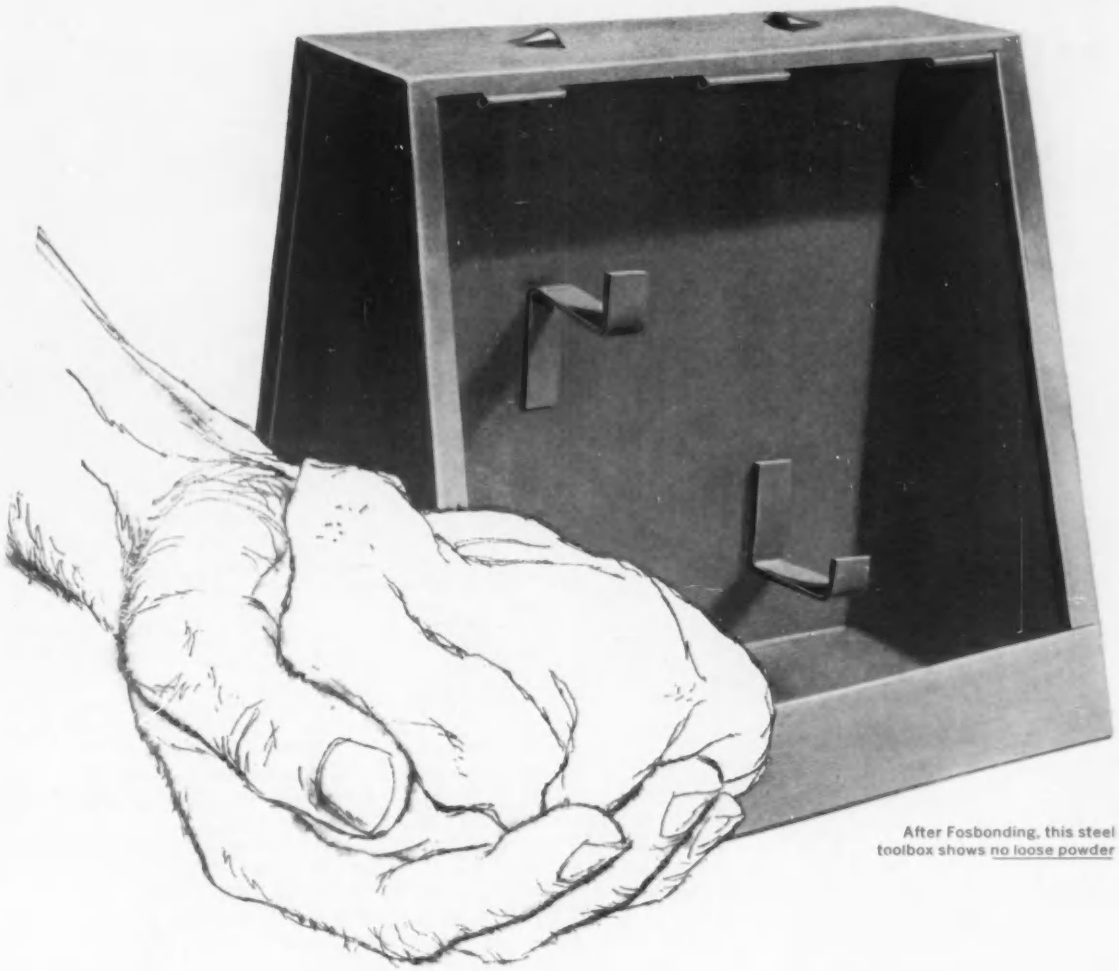


After Fosbonding, this steel toolbox shows no loose powder

Get powder-free iron phosphate coatings under organic finishes

with FOSBOND 22

Here's a truly dependable iron phosphate coating! Fosbond® 22 assures uniform, trouble-free phosphate protection of metal parts, cuts your finishing rejects to the bone. The balanced composition of Fosbond 22 prevents the highs and lows of ordinary phosphate films, and its superior cleaning power lets you clean and coat in one spray bath.

Shipped as a dry powder in a non-returnable drum, Fosbond 22 simplifies your storage and processing all down the line. In addition, long, economical bath life and improved corrosion-resistance under organic finishes help Fosbond 22 pay for itself in re-charge savings and lowered reject rate.

TRY IT IN YOUR CYCLE. See how this inexpensive, easily-controlled phosphate system cuts cleaning and coating costs. Where iron phosphate coating is indicated, you just can't match the simple Fosbond 22 process. Ask your Pennsalt representative for a demonstration in your equipment, or write Metal Processing Dept. 245, Pennsylvania Salt Manufacturing Company, Three Penn Center Plaza, Philadelphia 2, Pa. In Canada: Pennsalt Chemicals of Canada, Hamilton, Ontario.

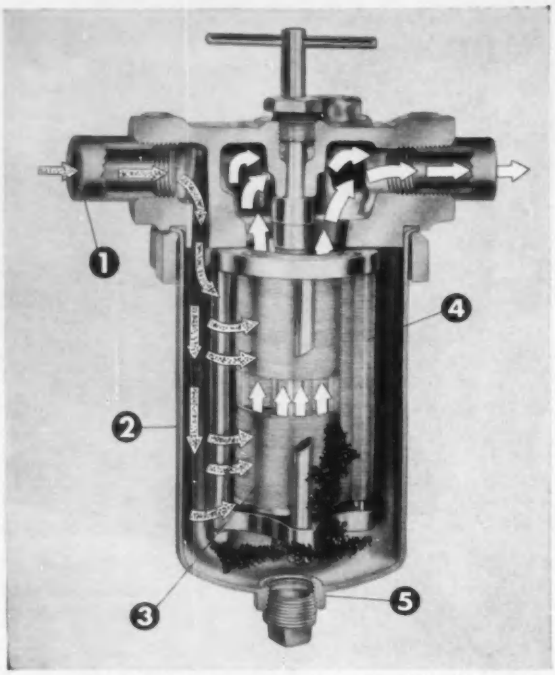
Pennsalt Chemicals

Metal Cleaners • Phosphate Coatings • Cold-Working Lubricants

A BETTER START FOR YOUR FINISH

NOW! 40-micron, self-cleaning filter

It's the new Cuno SUPER Auto-Klean



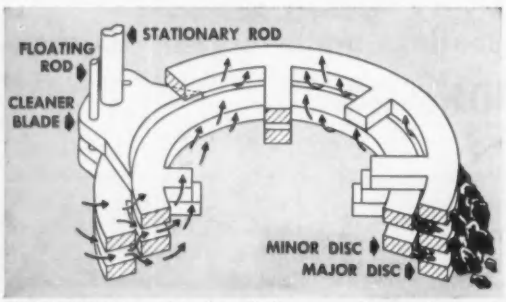
HOW IT WORKS. Dirty oil enters inlet (1) at left, fills housing (2) and flows through metal edge-type filter (3). Clean oil rises through center of filter, leaves at right. Dirt combed out by cleaner blades (4) is removed through drain (5).

Cuno's new SUPER Auto-Klean is the first practical, compact micronic filter for lubricating oil, hydraulic fluid, coolant, fuel, and other industrial fluids.

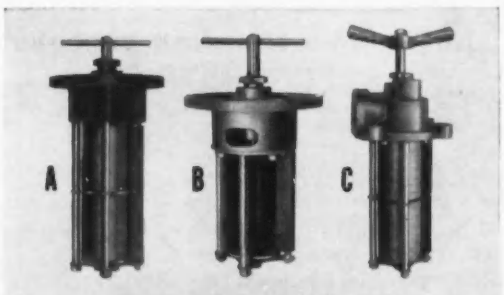
Many times smaller than other micronic filters of equal capacity, Cuno's new SUPER Auto-Klean filter now makes possible economical, micronic filtration at high flow rates and eliminates the need for replacement cartridges in most cases. Here's what it offers:

1. **Full-flow** 40-micron filtration with a self-cleaning filter. Positive protection against particles larger than 40 microns (actually 0.0015 in.). All-metal filter can't rupture or channel.
2. **Easy cleaning.** Just turn the handle—by hand or continuously with motor drive. No interruptions for cleaning.
3. **No cartridge changes.** Ends operating costs if you've been using cartridge filters.
4. **Low pressure drop, no pressure drop build-up.** An 8" by 2¼" SUPER Auto-Klean filters 30 gpm of 200 SSU oil with only 3 psi pressure drop—up to 75% more with slightly higher pressure.
5. **High capacity in a small package.** Many times smaller than replaceable-cartridge type filters of equal capacity, it saves with lower initial costs, lower installation costs.
6. **Easy to build into new equipment.** Available for line-type housings *(left)* or incorporation in sump or reservoir *(below.)* Works in any position.
7. **Easy to install in old equipment.** Fits existing Auto-Klean housings. You can easily replace most 2¼" diameter elements with SUPER Auto-Klean for finer filtration.

Write today for complete technical data on the new SUPER Auto-Klean for your new or existing equipment. Ask for Catalog No. SAK-057. Cuno Engineering Corporation, 20-2 South Vine Street, Meriden, Connecticut. 59



FILTER ELEMENT consists of stacked major and minor discs and cleaner blade bearing against minor discs. Small arrows show flow. Short restrictions between minor and major discs stop 40-micron particles but allow high flow rate.



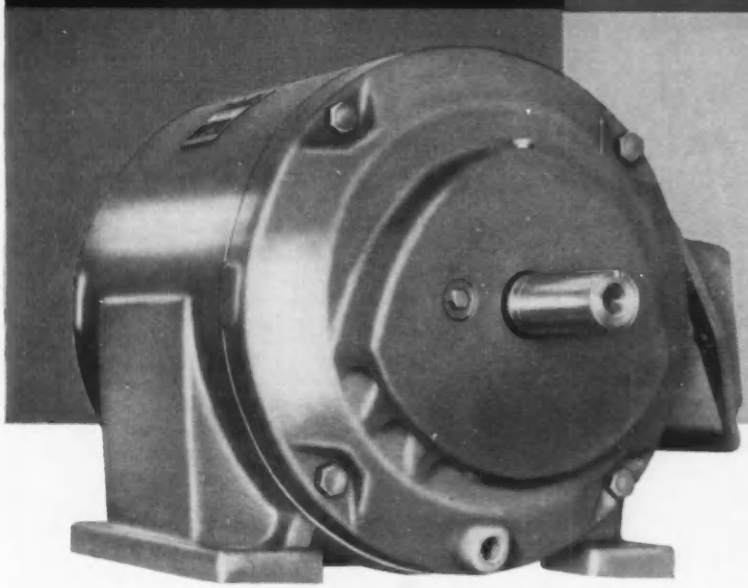
FILTERS FOR INTERNAL PIPING *(A and B above)* allow streamlined design plus the best infiltration. Flange mounting with external outlet *(C above)* and line-type *(large cutaway above left)* are just a few of many other possibilities.

CUNO **ENGINEERED FILTRATION**

Removes More Sizes of Solids From More Kinds of Fluids

AUTO-KLEAN (edge-type) • MICRO-KLEAN (fibre cartridge) • FLO-KLEAN (wire-wound) • PORO-KLEAN (porous metal)

Totally Protected



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RELIANCE *Totally-Protected* MOTORS

The total protection concept of design and construction armors Reliance A-c. Motors against everyday hazards, with little or no maintenance. Total protection is made up of extra features like:

Slot cell insulation of Double Backed Mylar

Dynamically balanced rotor for vibrationless operation

Entire insulation system impervious to acids, moisture and oils

Metering plate regulates grease flow to bearing

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There are 100 of these extra core to cover protection features in Reliance Motors. Each point is covered in our bulletin, "Check the 100 Facts". Why don't you write for one and get all the details? B-1810

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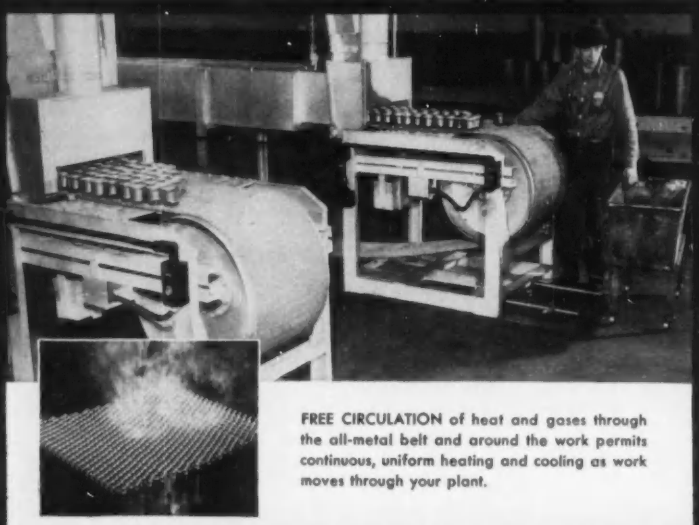
WOVEN WIRE CONVEYOR BELTS take the "hot spots" out of ANNEALING & BRAZING



FREE CIRCULATION of heat and gases through the all-metal belt and around the work permits continuous, uniform heating and cooling as work moves through your plant.

By combining controlled movement with free circulation of process atmospheres, Cambridge Woven Wire Conveyor Belts eliminate batch annealing and brazing. There is no formation of "hot spots" which produce local stresses. Continuous, belt-to-belt flow through subsequent quenching and washing operations as well as heating, cuts costs and provides fast, uniform production.

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. . . metalworking, food, chemical, glass and ceramic . . . whether the machines are for your own operation or resale, you'll find "free circulation" only one property of Cambridge belts that makes combined movement and processing practical and economical. Open mesh construction also provides rapid drainage of process solutions. Belts are corrosion resistant and impervious to heat damage, even at 2100°F. They have no seams, lacers or fasteners to wear more rapidly than the body of the belt. Cambridge Woven Wire Belts are made in any size, mesh or weave; from any metal or alloy. Special surface attachments are available to hold products during inclined movement.

Call in your Cambridge FIELD ENGINEER to discuss how you can cut costs by continuous operation. Look under "BELTING, MECHANICAL" in your classified phone book. OR, write for FREE 130-PAGE REFERENCE MANUAL giving mesh specifications, design information and metallurgical data.

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Department P, Cambridge 2, Maryland

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men or too prosaic to be good engineering managers. There are staff groups which are often intent on establishing innumerable obstacles to be circumvented only by the most crafty engineers, determined to get the job done in spite of the staff. Organizational division on the basis of technical or functional lines, project lines, area, or even some more radical denominator such as time, tend to make for poor organization.

No spectacle is more pathetic than an engineer who is held responsible for a project but is then thwarted by his own management in refusing him adequate authority. An atmosphere of impending upheaval—it is sometimes perpetual upheaval—can never bring out latent engineering talent.

It can be categorically stated that all management problems result from the actions of people. So one of the most important factors in any engineer's evaluation of a company or group is the quality of its people.

The question of a company's future is an important one in the minds of many engineers. It is a factor management should consider more carefully from the long range view than is now apparent.

The rather broad term "working conditions" covers many things which have been discussed and debated in both engineering and management circles. Engineers are individualists by their very nature, and rebel against regimentation. They will not be rigidly bound by time clocks or other restrictions. They have no objection to working long extra hours without compensation, if this effort is needed in special situations and is not a habitual practice. Conversely, however, they expect freedom and a liberal attitude towards time off for their personal affairs.

Little has been said so far of the engineer's responsibility in helping management. Too many electronics and other engineers, smugly aware of the current supply-demand ratio, take an independent attitude and refuse to compromise their differences or do their best work. However, an engineer has an important moral obligation: to carry out each assignment to the best of his ability. Executive problems are at times infinitely more difficult than the most challenging technical problem which do not involve people.

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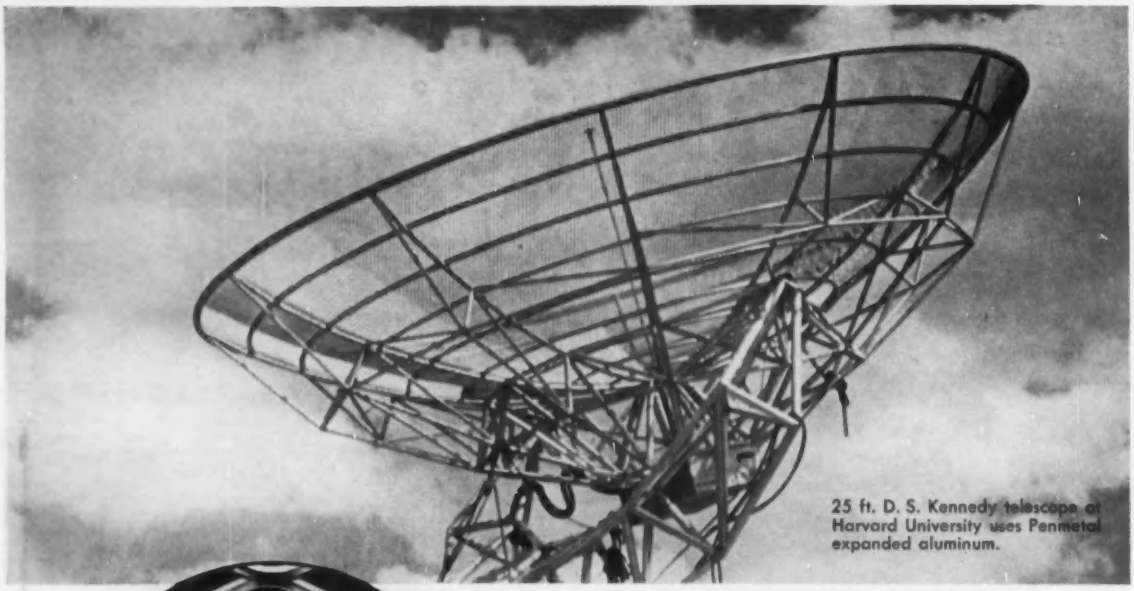
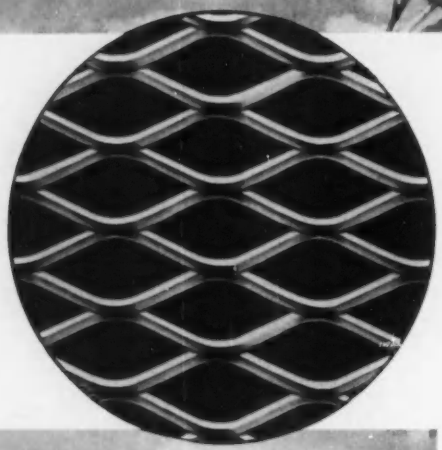
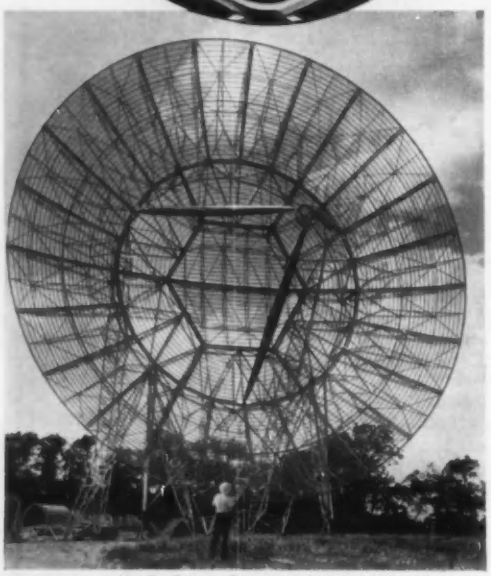


25 ft. D. S. Kennedy telescope at Harvard University uses Penmetal expanded aluminum.





Penmetal expanded aluminum covers entire area of 60 ft. Trans-Horizon antenna.

Why D. S. Kennedy & Co. prefers expanded aluminum for Radar Antennas

Over the past five years Penmetal has supplied a great deal of expanded aluminum to leading manufacturers of microwave and radar antennas. An example is D. S. Kennedy and Company of Cohasset, Mass.—many of whose developments have become standard specifications in the industry. They use Penmetal expanded aluminum to cover the entire area within the outer periphery of their antennas. Reasons:

- **EXTREME LIGHTNESS**—large areas can be covered with a minimum of weight.
- **MAXIMUM OPEN AREA**—for minimum wind resistance.
- **CORROSION-RESISTANT**—for long life under all weather conditions.
- **LOW COST**—large areas can be covered economically.
- **EASILY FABRICATED**—with standard tools.

As we have done with D. S. Kennedy & Co., Penn Metal will work closely with your engineers in producing special-purpose meshes for your requirements.

Best way to success when you make radar and microwave antennas is Penmetal expanded aluminum. Write for free folder which describes this material in detail.

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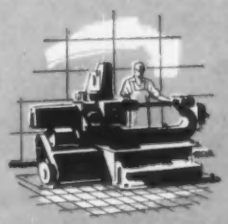
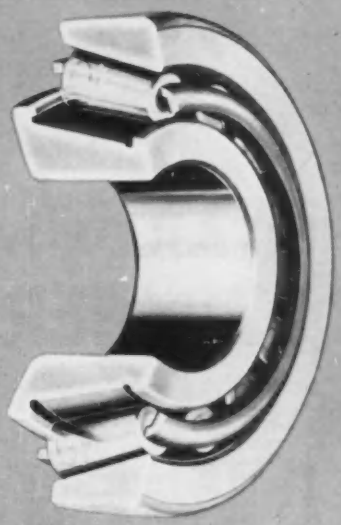


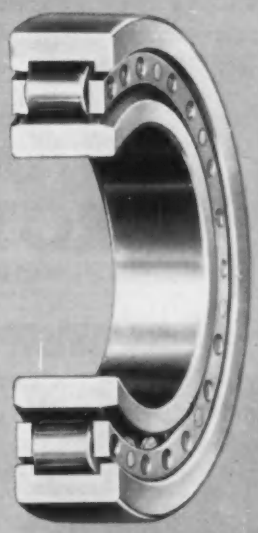
Job-tailored in a wide range of sizes to fit your specific needs

Aircraft? Automobiles? Earth-moving or farm equipment? *Whatever* you make, if your product uses straight or tapered roller bearings, Bower can meet your specifications *exactly*. For dependable Bower bearings are virtually custom-built to the job . . . engineered and sized to match any requirement.

Important, too, are exclusive Bower design features that assure long life, top performance, *less maintenance*. And when you specify Bower bearings you can always be certain of the highest quality materials and workmanship. These reasons, of course, are why Bower straight, tapered and journal roller bearings are used by leading manufacturers everywhere—for any application.

Let a Bower engineer give you full details of the complete Bower line. Call him in while your product is still in the design stage.





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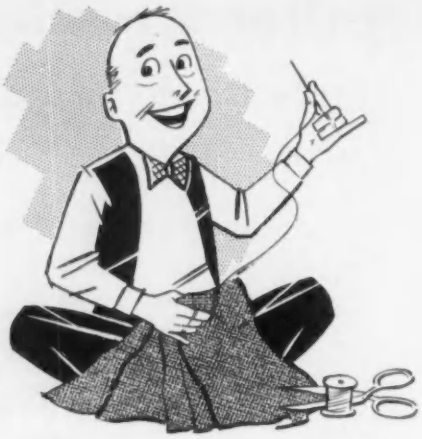

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NEW BOOKS

Instruments for Measurement and Control

WERNER G. HOLZBOCK, *Development Engineer, Askania Regulator Co.* 6 x 9 *in.*, 371 *pp. Published by Reinhold Publishing Corp.*, 430 *Park Ave., New York* 22, *N. Y.* $10.

This book is the first to describe and illustrate all the most recent devices for measuring and controlling temperature, moisture, pressure, flow, uniformity. In non-mathematical language, the book discusses the design, construction and operation of instruments, shows how various instruments compare with each other, and points out the factors to consider in choosing the proper instrument for a particular job.

Process variables and commercially available instruments for their measurement, analytical process instrumentation, devices used in controller actions, and such final control elements as valves, pumps, transformers and motors, are fully covered. A chapter on trends discusses the development of centralized systems, miniaturization and digital computers.

Hydraulic and Pneumatic Power for Production

HARRY L. STEWART, 6 x 9 *in.*, 416 *pp. Published by Industrial Press*, 93 *Worth St., New York* 13, *N. Y.* $8.50.

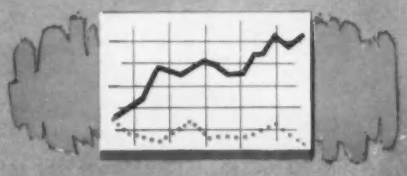
With the increasing use of hydraulic and pneumatic actuation there has been a growing need for a good general reference book on the subject. This book goes far toward answering that need with clear description and illustrations of the many problems and solutions possible.

Of particular value is the careful coverage of the components that make up air and hydraulic systems (pumps, valves, cylinders), including a list of likely operational troubles and their correction. Each component is shown in operation in a typical

(Continued on page 360)

PRODUCT SALEABILITY IS A BASIC REQUIREMENT OF SUCCESSFUL DESIGN

Resistance welding can lower your cost of fabrication

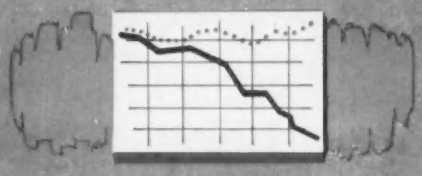


INCREASES PRODUCTION

Why take the time to drill a hole and then fill it with a bolt or rivet? The utter simplicity of Sciaky resistance welding reduces multi-step fastening operations to just one! Actually, it's quicker to make a spot weld than to drill the hole. (Often less time even than *punching* the hole!) Automatic welder operation and feeding allows greater production economy than any other method of fabrication.

REDUCES LABOR DEMAND

The operation of a Sciaky welder is automatic. Control functions are preset and only one operator (not skilled) is required to produce consistent, high quality welds in high production. Ease of operation reduces operator fatigue and minimizes danger of human errors. Routine service, set-up and production control for a whole battery of Sciaky welders are readily handled by just one man.



LOWERS OPERATING COST

The production capability, the elimination of additional materials for fastening (rivets, bolts, rod, etc.), and the lack of expensive jigs and fixtures—these advantages explain the impressive operating economies of Sciaky resistance welding. Further, only one operator (not skilled) is required. Skilled workers and extra helpers are released for other operations.

DEPENDABLE AND CONSISTENT

Beyond structural integrity, the unusual dependability and consistency of Sciaky welder operation is the result of a refinement of mechanical design and electronic control. That is why Sciaky designs and builds electronic controls to satisfy each specific welder application. Mechanical functions are carefully considered, and components are designed by Sciaky for the same reason.

Greater Economy, Increased Production For Your Design

When Sciaky Patented Three-Phase Resistance Welding Is Specified!

LOWER INSTALLATION COSTS—Invented, patented and pioneered by Sciaky, the Three-Phase principle of welder operation offers direct savings . . . lower installation cost, smaller distribution lines, and smaller switch gear than conventional single phase . . . no need for extensive compensators or capacitors to improve welding conditions.

LOWER POWER BILLS—Sciaky balanced load Three-Phase with 85% power factor (compared to approximately 30% of conventional single phase), and 50% reduction in power demand, is far less expensive to operate than conventional single phase unbalanced load welders.

GREATER WELD CONSISTENCY—The equalizing current characteristics of Sciaky patented Three-Phase results in much greater weld consistency. Sciaky Three-Phase will maintain the weld quality at a given control setting throughout the longest production run.

MUCH LONGER ELECTRODE TIP LIFE—Sciaky patented Three-Phase with its characteristic progressive current rise and inherent lack of skin effect greatly extends electrode tip life. Electrodes have much longer life, and the need to stop production to dress them is far less frequent.

Regular issues of "Resistance Welding At Work," containing detailed examples of Sciaky resistance welding applications, are available to you. Read how other companies, large and small, have improved their product and lowered operating cost . . . impressive examples of Sciaky's basic thinking—welders designed to do *more work at lowest operating costs* with *maximum reliability!*

Largest Manufacturers of Resistance Welding Machines in the World

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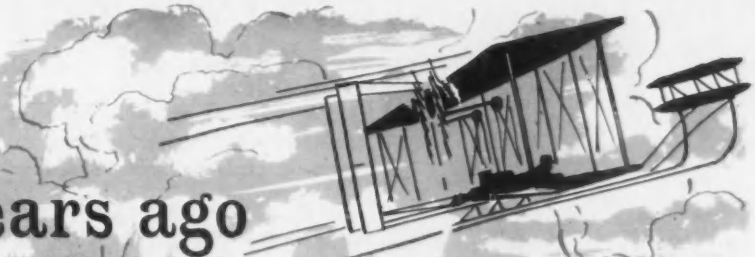

and 22 years before the Wright Brothers made the first successful airplane flight

Koven was making individualized equipment parts

Today we take airplanes for granted . . . accept them placidly, without surprise, just as we accept the beneficial effects of heavy-scale mass production. Yet the beginnings and maintenance of every great undertaking require struggle and enterprise.

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For efficient individualized equipment parts built to your exact needs, call or write for a consultation with a trained KOVEN representative, and send for Bulletin #550. There's no obligation.

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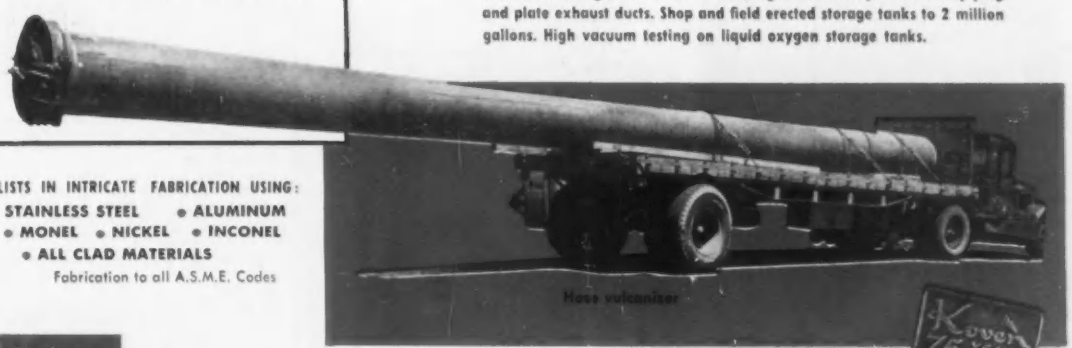

Hose vulcanizer

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circuit and the sequence of actuation and control completely described.

Properties of hydraulic fluids of petroleum and synthetic types are covered, including some difficulties and remedies in their use. Succeeding chapters cover hydraulic pumps, filters, accumulators, pipes, valves, cylinders, motors and heat exchangers. One valuable chapter describes various methods of cylinder synchronization and another covers safety control circuits. An extensive chapter on packings and seals covers materials (leather and synthetic) as well as many of the shapes and forms of seal design.

In a similar way, air filters, lubricators, regulators, controls and cylinders are described. Additional chapters are devoted to pneumatic safety circuits, remote control pneumatic systems, and various types of air-operated holding devices.

Certainly many of the subjects covered would warrant books by themselves, but for its size this one volume offers more than many others of much narrower scope. What is sorely lacking is an extensive bibliography of published material in the field to which a reader could refer for detailed information on any single particular subject.

Hawley's Technical Speller

G. G. Hawley, *Executive Editor* and A. W. Hawley, *Consulting Editor*. 5 x 7½ *in.*, 146 *pp. Published by Reinhold Publishing Corp.*, 430 *Park Ave., New York* 22, *N. Y.* $2.95.

Over 8000 difficult technical words are listed here from the vocabularies of chemistry, physics, engineering, electronics, biology and medicine. No definitions are included, but preferred divisions of words should be of help to engineering secretaries.

Noise-Reduction Manual

P. H. Geiger, 6 x 9 *in.*, 167 *pp. Published by University of Michigan Press, Ann Arbor, Mich.* $5.

Originally prepared under the auspices of the Office of Naval Research, this volume is intended as a practical aid to noise control rather than an elaborate acoustical reference work.

It starts with a review of the princi-

(Continued on page 364)

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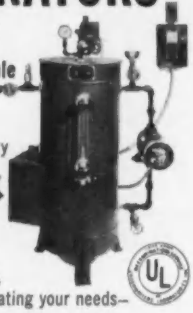

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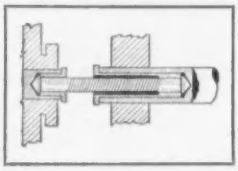

Coupling is used for the transmission of power or control of movement between parts located close together in a piece of equipment. It is not a separate type of flexible shaft but rather an added application of flexible shafting.

The coupling can be composed of either power drive or remote control flexible shafting although the latter is generally used due to the added advantage of its ability to rotate both clockwise and counter clockwise. Generally used between two units which are but a few inches apart, coupling may transmit power between any two parts regardless of their relative positions.

For example, the diagram above shows an advantage in using small lengths of flexible shafting in a coupling application. Although the drive end and the driven end are not exactly in line, the coupling compensates for the difference in alignment between the two.

Many manufacturers use flexible shaft coupling even where parts may be connected by solid shafts because of the savings realized in the initial and the maintenance costs as well as in time and labor.

For complete information on how flexible shaft couplings may help improve your product design, write F. W. Stewart Corporation, A Subsidiary of the S. S. White Dental Mfg. Co., 4311-13 Ravenswood Avenue, Chicago 13, Illinois.

"coated...to quiet the clatter"

That's why Geneva Modern Kitchens, Geneva, Illinois, coat kitchen cabinet shelves with plastisols based on BAKELITE Brand Vinyl Dispersion Resins.

"The 'whisper-quiet' shelves have a smooth, shiny surface that will not attract dirt, is easy to clean, and has a rich warm feel," says R. W. Sponholtz, Vice President. "The coating provides a cushion for delicate china and glassware, yet is highly resistant to abrasion, corrosion by moisture, food and beverages. These features add much to the quality of our line."

Does your product require a coating that resists abrasion yet is soft and resilient? Or must it resist sun, chemicals, corrosion, flexing? The answer may be plastisols based on BAKELITE Brand Vinyl Dispersion Resins. For more specific information and a list of suppliers, write today to Dept. NC-145.

This shelf was dip-coated, followed by a short bake at moderate temperatures. Slush molding or injection molding with little or no pressure are other methods of using plastisols. Almost any color can be obtained and finishes can be glossy or matte. Coating for this Geneva Modern Kitchen shelf formulated by **Michigan Chrome and Chemical Co.**, Detroit, Mich.

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- **each unit service tested—with steam.**

When less than the best won't do, specify Nicholson.

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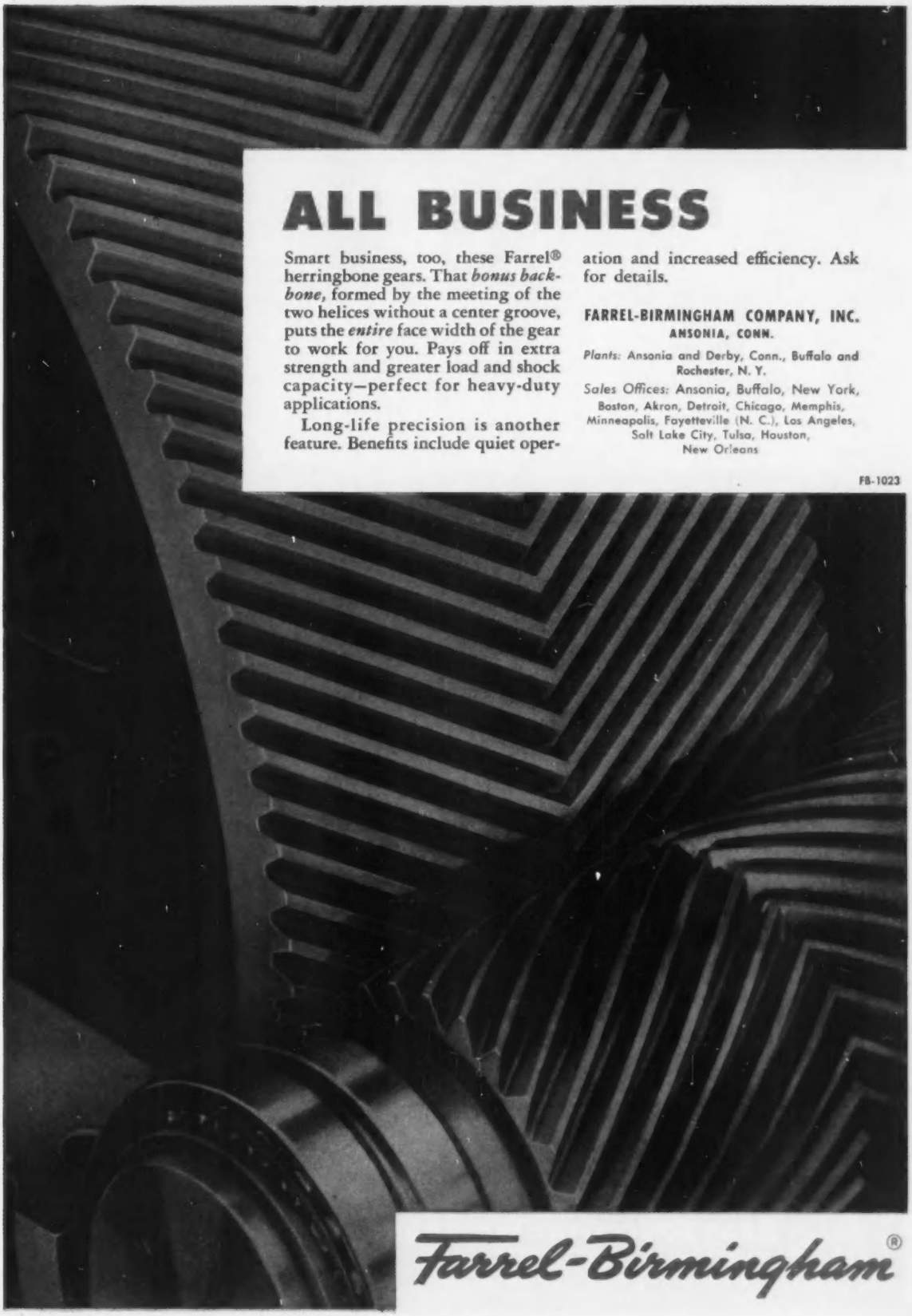
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pal means by which sound waves radiated to the environment by a machine can be reduced. Specific methods are offered and sample installations described.

A short but useful chapter is included which defines the terms and mathematical units used in noise reduction work. Brief descriptions of psychological loudness, sound level, bend pressure level and pressure spectrum level provide the basic concepts and terminology required by the investigator.

Subsequent chapters give detailed information on sound absorption and insulation, vibration damping, vibration isolation, and the instruments and techniques used to measure and analyze the sources and control of sound.

Progress Through Invention

6 x 9 in., 28 pp. Published by Publications Committee, Cleveland Engineering Society, 2136 E. 19 St., Cleveland 16, Ohio. $1.

This booklet contains papers which discuss the elements that go to make a successful invention, inventors' relations with the U. S. Patent Office, marketing of inventions. The individual papers included were all delivered at an Invention Exhibit and Conference sponsored by the Society in Aug., 1954.

Fifth Symposium (International) On Combustion

The Standing Committee on Combustion Symposia of the Combustion Institute, 7 x 10 in., 802 pp. Published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y. $15.

This is a bound volume of 101 outstanding papers presented at the Fifth Symposium held at the University of Pittsburgh in 1954.

It includes the works of 182 contributors from various countries, including England, Canada, France, Australia, Belgium, Japan and Germany. Representing the most complete and authoritative collection of data ever assembled on combustion problems, their papers cover the following areas: Review of Problems on Combustion in Engines and Kinetics

(Continued on page 368)

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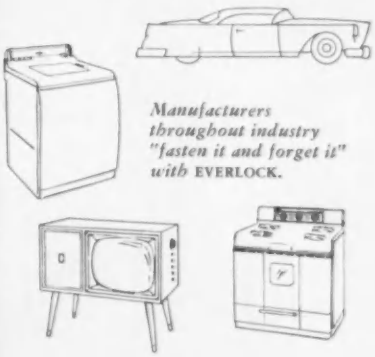

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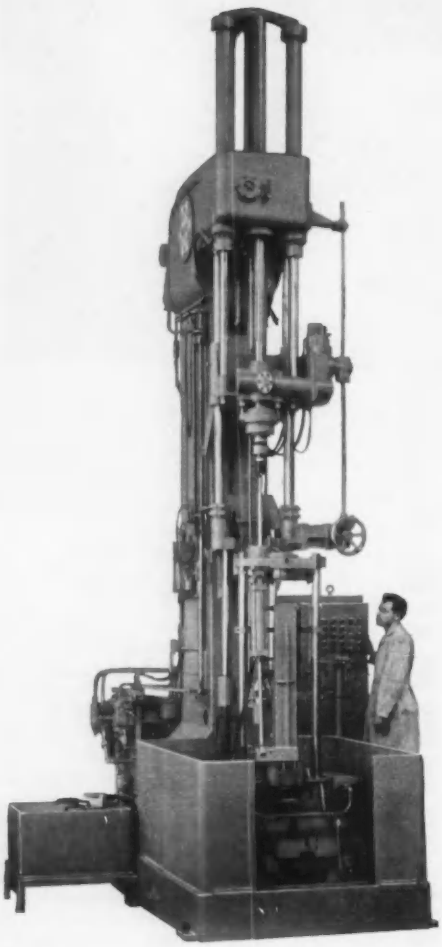

INCREASINGLY, process engineers are recognizing Microhoning's low-velocity abrading technique as a means of combining efficient stock removal with precision.

The Brooklyn Works of American Machine & Foundry Company, in the precision-manufacture of recoil mechanisms for artillery weapons, required a process that would most efficiently remove substantial amounts of stock and generate functional surface characteristics on the I.D. of recoil cylinders and O.D. of piston rods. After extensive study of available methods, AMF selected Microhoning as the most productive and economical process for obtaining desired results.

The floating piston in the recoil cylinder has nitrogen gas on one side and hydraulic oil on the other. Because silver ring seals are used, any error in geometry or roughness of cylinder or rod surfaces will induce deformation or scoring of silver rings and break these important seals.

The largest cylinder processed by AMF to date is for a 75 mm gun and has a bore diameter of 4.750 inches and a length of 46 inches. Piston rods for this gun are 1.375 inches in diameter and 56 inches long. Both I.D. and O.D. operations are on the same Microhoning machine—Model 450 Hydrohoner.

The Microhoning process efficiently removes up to .026 inch of stock from cylinders and .006 inch from rods to correct waviness, taper and out-of-roundness. A geometric tolerance of .0001 inch is held while obtaining a 1.5 microinch finish.

Working closely with AMF manufacturing personnel, Micromatic developed fixtures and tooling that minimize changeover time. The fixture for the cylinder is mounted on an indexing table so it is simply indexed away from the spindle while the rod is being Microhoned. You, too, can solve your precision stock-removal problems through application of Microhoning—the low-velocity abrading process.

For further information write for CROSS-HATCH, Vol. 7 No. 5

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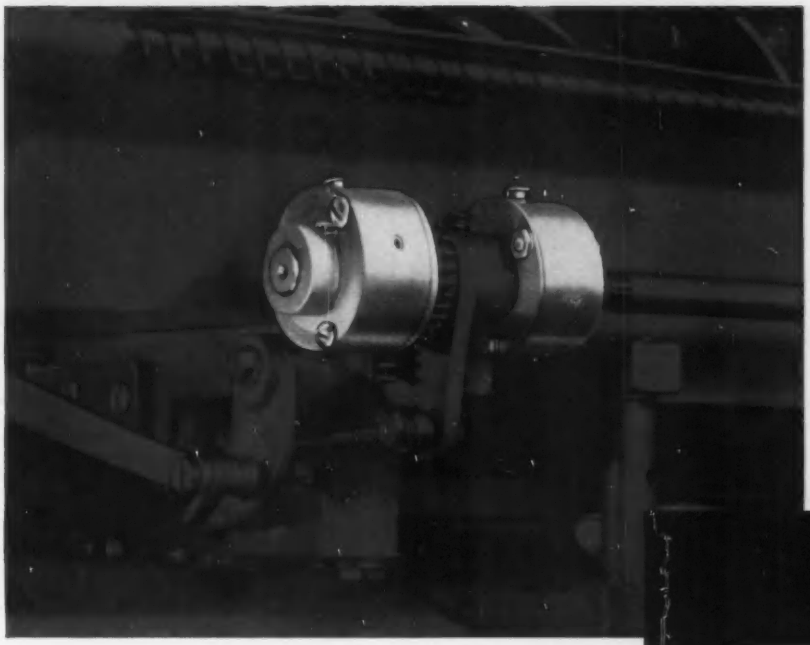
Stock Removal + Geometry + Size Control + Surface Finish

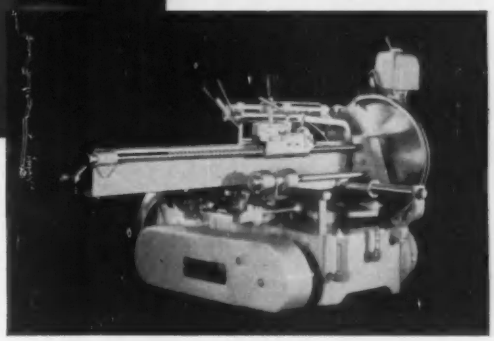
MICROMATIC HONE CORPORATION

8100 SCHOOLCRAFT AVENUE • DETROIT 38, MICHIGAN

Morse Cam Clutches make slicing machine infinitely more accurate



Series 200 Cam Clutch with retaining end plate removed. This Cam Clutch Series fits standard Series 200 bearing housings.



Here's how they work:

The first Morse Series 200 Cam Clutch controls indexing (though not required on this job, it can handle up to 500 indexes per minute). When driven in one direction, inner and outer members rotate as one unit. When driven in the other direction, one member overruns freely, other member remains stationary. The second Cam Clutch is used to prevent backfeed between strokes.

Versatile, compact clutches can help designers control indexing, free-wheeling, backstopping

This modern slicing machine is infinitely more accurate because a Morse Cam Clutch replaces the old ratchet and pawl mechanism controlling the feed.

When U.S. Slicing Machine, Inc., used the ratchet and pawl, feed variations (slice thickness) could only be made in 1/128-inch increments. Now, the Morse Cam Clutch provides, in effect, a self-contained ratchet with an infinite number of teeth . . . and literally makes it possible for the machine to slice accurately to *any* desired thickness.

In addition, another Morse Series 200 Cam Clutch is used as a backstop device to maintain one-directional drive. It instantly engages to prevent backfeed between forward strokes.

Morse Cam Clutches are manufactured in capacities ranging from 4½ inch-lbs. to 20,000 ft.-lbs. Their low-cost accuracy and dependability make them ideal for a wide range of industrial indexing, overrunning, and backstopping applications.

Like other precision-built Morse power transmission equipment, they are quickly available from your local Morse Distributor. For more information, or free Catalog C 11-54A, call him, or write us today. MORSE CHAIN CO., INDUSTRIAL SALES DIVISION, ITHACA, N. Y.

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CHAINS, CLUTCHES, AND COUPLINGS

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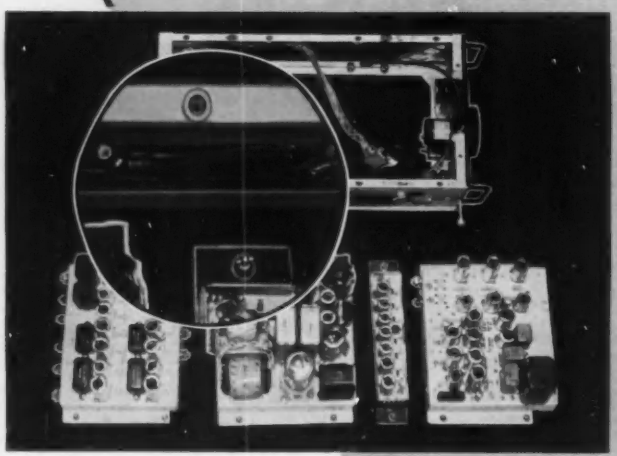
RCA's new C-Band air-borne weather mapping radar unit marks a big-step toward all-weather commercial air transport service . . . a major contribution to added efficiency, safety and comfort in flight.

Efficient and safe, too, are the Camloc quarter-turn fasteners that hold the C-Band's electronic assemblies firmly in place. A quarter-turn and the Camloc fastener is opened fast. A quarter-turn and the Camloc fastener is closed fast—to hold fast!



Electronic components in this RCA C-Band radar accessory unit are assembled in groups for quick and easy servicing. Camloc quarter-turn fasteners provide the fast-acting, firm-holding means of insuring quick accessibility on the ground, vibration-proof operation in the air.

Camloc fasteners and latches are serving the aircraft and electronics fields in hundreds of ways. There's a Camloc device to meet your fastening needs, too. Write for complete information.

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The Automatic Factory—A Critical Examination

STEPHEN A. JUNE, JOHN D. BARDIS, LEE H. LURIO, LEONARD S. POLANER, OYSTEIN SAGEDAHL, HERBERT A. SKLENAR, BERNARD K. YENKIN. 8¾ x 5¾ *in.*, 88 *pp. Published by Instruments Publishing Co.*, 845 *Ridge Ave., Pittsburgh* 12, *Pa.* $1.50.

Directed primarily to management to give a clear unbiased analysis of the present status of the automatic factory together with a reasoned guess into the future. The authors spent six months on the research, which included personal interviews with leading authorities, sending out questionnaires, studying the literature and organizing the many facets of the problem.

The conclusions reached clearly show the tremendous effect the trend to automatic control will have on production techniques but skirts almost completely the effect on equipment design. Engineers would do well, however, to spend the hour or so necessary to read this book, since automatic production affects design.

Transistor Electronics

A. W. LO, RICHARD O. ENDRES, J. ZAWELS, F. D. WALDHAUER, and CHUNG-CHIH CHENG *of RVA Laboratories.* 6 x 8¾ *in.*, 521 *pp. Published by Prentice-Hall, Inc., Englewood Cliffs, N. J.* $12.

This book is the combined work of five authorities in the field of electronics. It presents a fully integrated approach to the theory and practice of transistors and transistor circuits.

First presented is a qualitative treatment of the physical concepts essential to understanding transistors. This is followed by analyses of fundamental transistor networks and circuits, also summarized in tabular form.

A large number of illustrated repre-

(Continued on page 372)

What every designer should know about

FACE GEARS for Angular Drives

FACE GEARS have distinct advantages which the designer should know. They can be spur or helical, "on-center" or "off-center." The mating members are pinions. Both are generated on Fellows Gear Shapers by cutters having involute teeth.

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- easier and lower cost assembly
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- pairing for reversal of direction
- tooth bearing not affected by axial displacement of pinion

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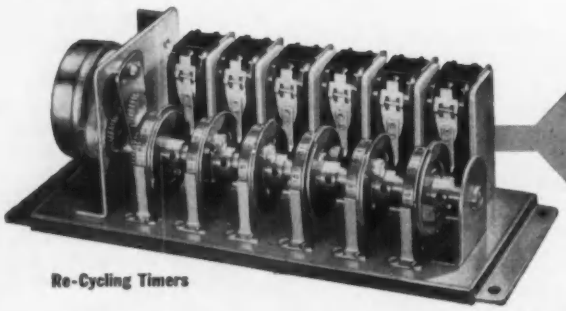

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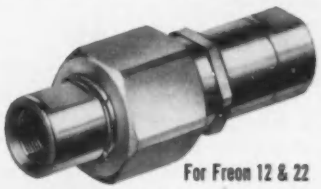

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Aeroquip 511017 Self-Sealing Coupling for refrigeration and air-conditioning applications makes low cost field installation possible by permitting factory charging of the units and lines of various lengths. Mates with sweat-type adapters.

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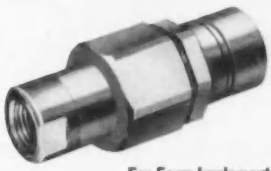
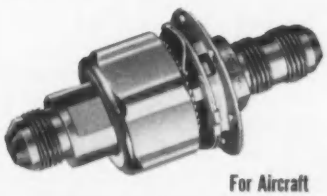
Aeroquip 5102 Self-Sealing Coupling speeds recharge of LP-Gas fuel tanks on trucks, tractors. Coupling has Acme and P.O.L. threads to fit any recharge line. Absolutely no leakage of fuel upon connecting or disconnecting.



For Farm Implements

Aeroquip 5203 Self-Sealing Coupling provides quick, easy interchange of hydraulic trailing and tractor-mounted equipment. Mates with the Aeroquip Breakaway.



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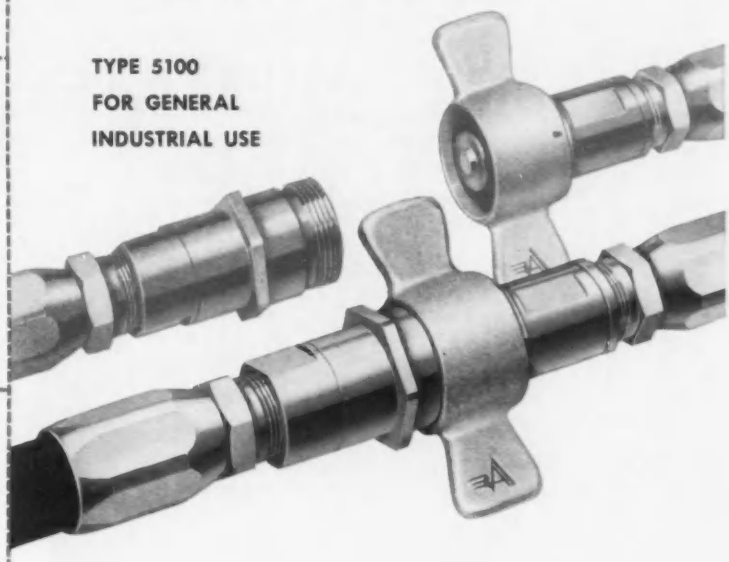
Aeroquip 155 & 145 Self-Sealing Couplings speed inspection, servicing or replacement of engines and other aircraft fluid system components. Ideal for engine test stands.

TYPE 5100
FOR GENERAL
INDUSTRIAL USE



Aeroquip Self-Sealing Couplings permit quick connection and disconnection of fluid lines under pressure, without loss of fluid or inclusion of air into the system.

Type 5100 coupling has a wide range of industrial uses on air, water, hydraulic, fuel and lube oil lines. It is ideal for stationary and mobile equipment where fluid-carrying lines must be disconnected and reconnected frequently for servicing, moving, or interchanging of parts and accessories.

CATALOG No. 200 contains complete information on Aeroquip Self-Sealing Couplings and flexible hose lines with reusable fittings, plus valuable fluid line data. Write for your copy.

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sentative circuits are included to assist in an understanding of circuit operation and practical circuit design. The book discusses transistor operation at high frequencies. Practical design procedure for high frequency amplifiers, a detailed treatment of transistors in non-linear, large signal operation, and a full explanation of oscillators, modulators, detectors and computer-type switching circuits are also included.

Recommended for anyone interested in transistors.

Information Processing Equipment

Edited by M. P. Doss, *Technical and Research Div., Texas Co., 6 x 9½ in., 270 pp. Published by Reinhold Publishing Corp., 430 Park Ave., New York 22, N. Y. $8.75.*

All equipment used in the preparation, reproduction and utilization of written information are described and illustrated in this useful book. How to process this information or data of any sort from any source; how to handle it; and how to store it are presented as solutions to the problems involved in today's mountain of paper work.

Each chapter is written by one or more recognized authorities in the particular field discussed; they cover latest developments in such informational media as electric and automatic typewriters, calculating machines, stencil and hectographing equipment, collating machines, lens-less copying with sensitized paper, industrial photography, microcopying, letterpress and offset printing, dictating and recording machines, punched cards, machines for handling numerical data and many others.

Vector Analysis

Homer E. Newell, Jr., *Physicist, Naval Research Laboratory, Lecturer in Mathematics, University of Maryland. 9¼ x 6¼ in., 207 pp. Published by McGraw-Hill Book Co., 330 W. 42 St., New York 36, N. Y. $5.50.*

Vector analysis, when used with skill and understanding, can be a useful and powerful tool for the engineer and physicist. The subject is

(Continued on page 377)

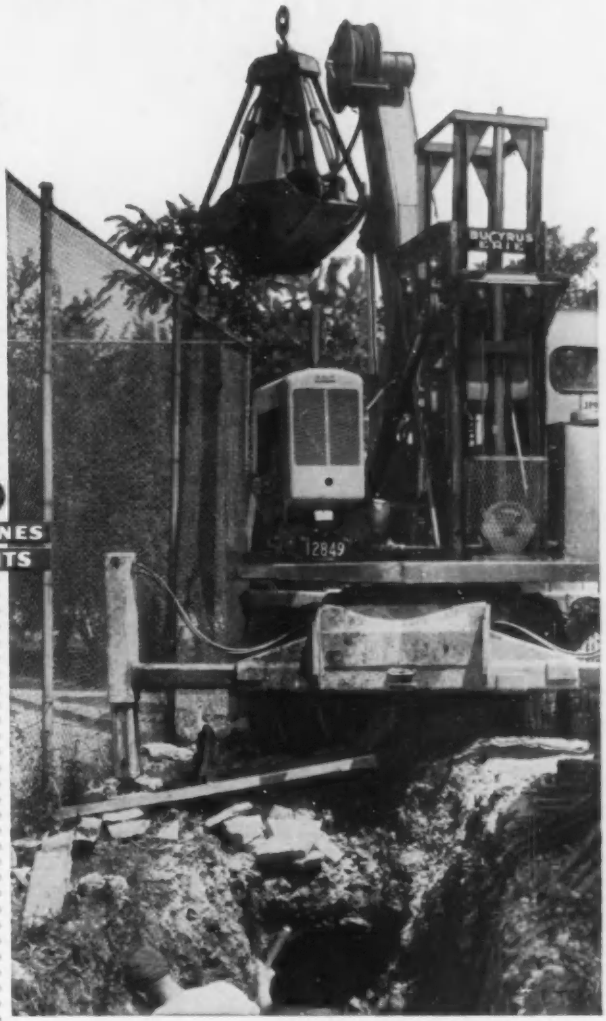
"FORD POWER STARTS QUICKLY

hangs on to heavy loads — doesn't hesitate a bit!"

says FREDERICK VOLK, Fox Point, Wis.

"We handled approximately 60 cubic yards in close quarters with the clam shell in about three hours work. We were digging a drainage trench for a 42" culvert and had to go around various obstacles including trees and a 12-ft. fence to swing the clam over with the load. I like the Ford power of this Hydrocrane because it starts quickly—hangs on to heavy loads and it doesn't hesitate a bit!"

Ford
INDUSTRIAL ENGINES
AND POWER UNITS



The Bucyrus-Erie Model H 3 Hydrocrane that Mr. Volk operates for the village of Fox Point is powered by a Ford "172" industrial engine. Built for versatility, mobility and economy, the Hydrocrane gives precision control through a hydraulically operated closing bucket and a variety of attachments. Upper deck revolves 360° with telescoping high-lift boom capable of from 30- to 38-ft. full load length. Hoist rams provide free line speed of up to 190 f.p.m. with 6,000 lbs. line pull. Ford Industrial Engines can provide similar power plants for all the major types of construction equipment.

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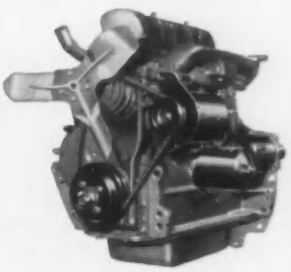

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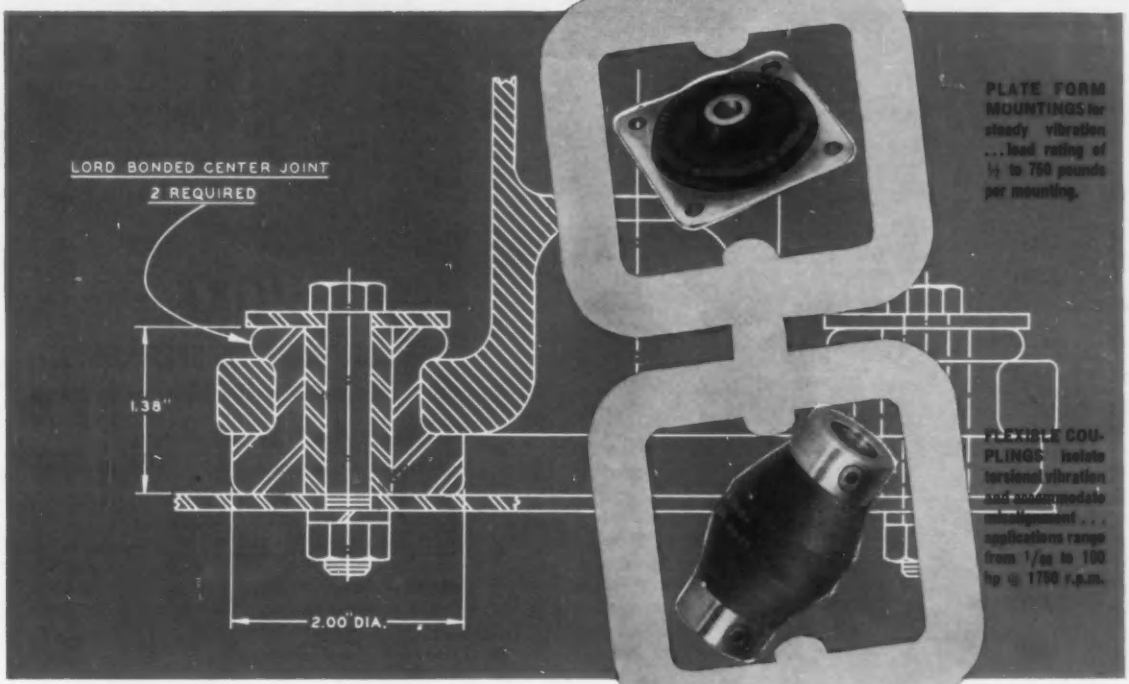
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not especially difficult, and with a moderate amount of effort one can acquire facility in the application of vector methods to physical problems.

This text is intended to develop the algebra and calculus of vectors in the way in which the physicist and engineer will want to use them. Much of the meat of the course is in the problems, which are designed not only to furnish practice in manipulation, but also to establish vectors and vector concepts in the physical and geometric intuition of the student.

Part I, the basic portion of the text, is devoted to a thorough treatment of vector algebra and the vector calculus. Part II provides the illustrative matter, presenting applications to kinematics, mechanics and electromagnetic theory.

Electronic and Radio Engineering

FREDERICK E. TERMAN, *Dean of the School of Engineering, Stanford University, California.* 9¼ x 6¼ *in.*, 1078 *pp. Published by McGraw-Hill Book Co., Inc.*, 330 W. 42d St., New York 36, N. Y. $12.50.

This is a new and thoroughly revised edition of Terman's *Radio Engineering* which has an increased emphasis on general techniques of electronics, as well as complete coverage of all important electronics engineering aspects.

This edition presents a comprehensive treatment of the basic engineering knowledge relating to vacuum tubes, transistors, electronic circuits and radio systems that represent the working tools of every electronic and radio engineer. The book has three parts: the first deals with transmission lines, covering the basic circuit theory peculiar to electronics; the second deals with electronic engineering, including a thorough treatment of electronic devices and their applications; the third covers radio engineering and systems peculiar to radio communication.

The text has been completely rewritten, every figure has been redrawn, and most of the figures are entirely new. A new chapter has been added on microwaves, which presents for the first time a simple ex-

(Continued on page 378)

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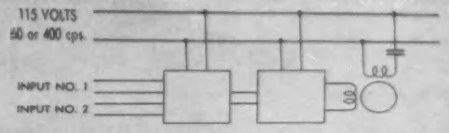

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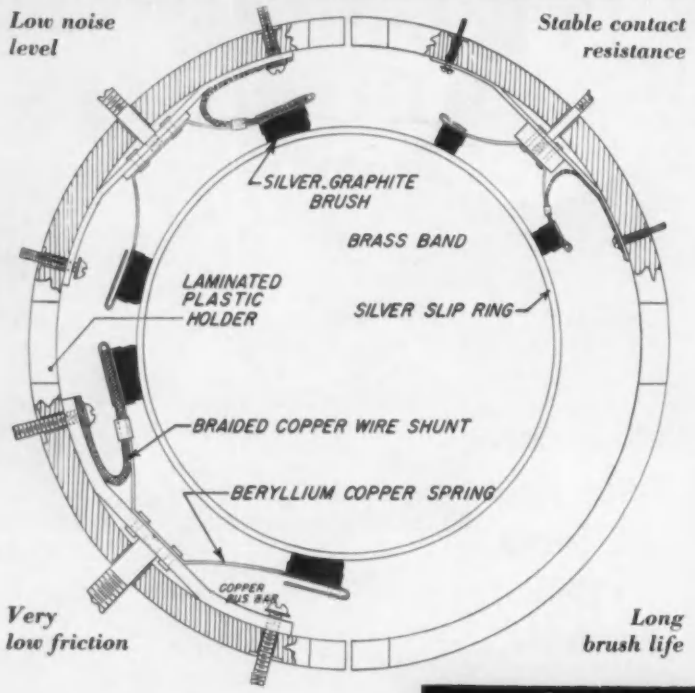

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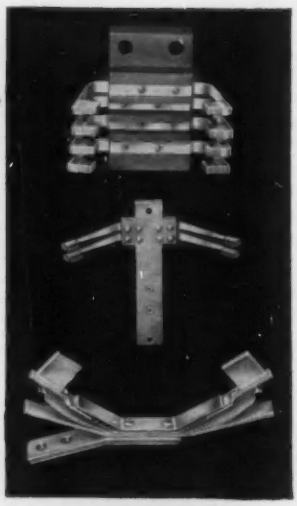

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planation of how the traveling wave tube and the backward-wave oscillator (carcinotron) operate. A relatively long chapter has been included on semiconductors and transistors, which relates the physical phenomena occurring within the device to the characteristics observed at the terminals. The chapter on television has been completely revised, and now includes an explanation of how the U. S. standard color television system operates. Over 1250 problems and exercises aid the reader in determining his comprehension of the various aspects of the field.

Gear Design and Production

REGINALD TRAUTSCHOLD, 6 x 9 *in.*, 204 *pp. Published by Columbia Graphs, Columbia, Conn.* $4.50.

Main purpose of this book is to restate the principles of gearing concisely, prove the rules, and give convenient formulas for the many critical computations entailed in gear design. Various standard varieties of gear units and applications are discussed. However, only a small portion of the book deals with production methods and tolerances.

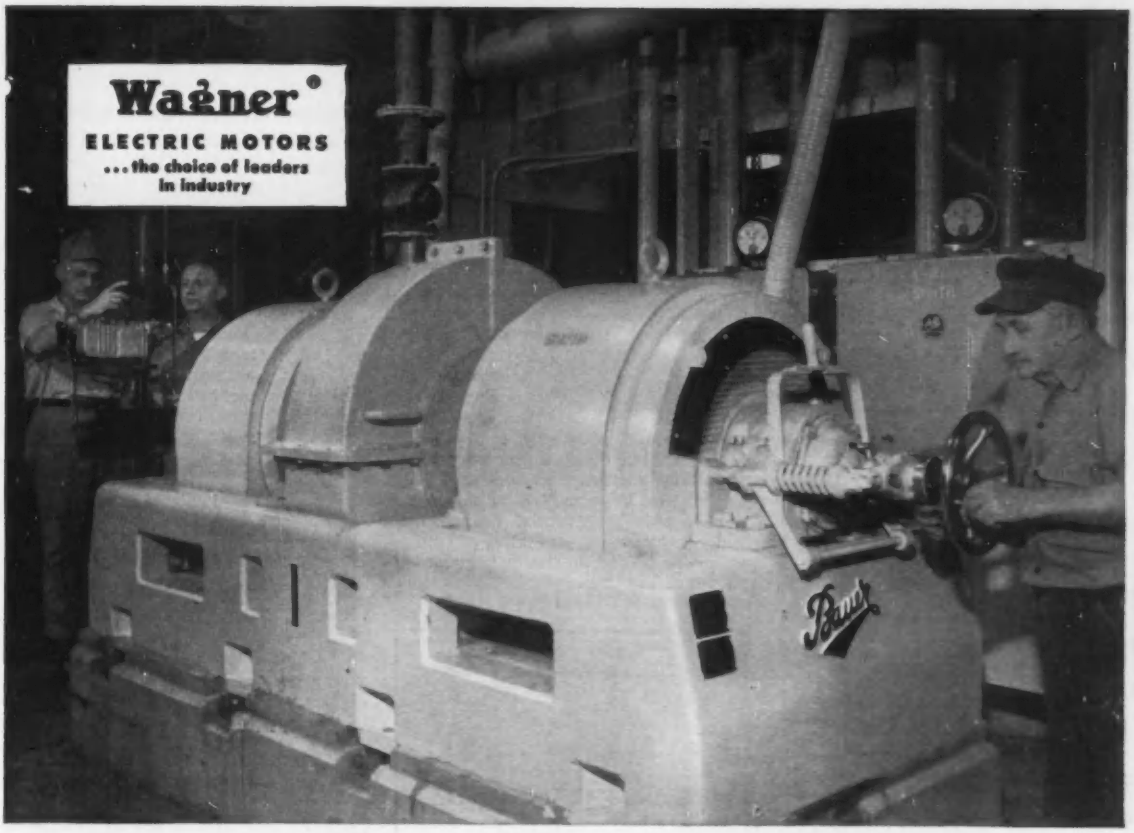
Chapter headings are: gear tooth profiles, speeds and power, tooth and gear proportions, spur gear computations, bevel gearing, helical and herringbone gearing, spiral gearing, worm gearing, spiral bevel, skew bevel and hypoid gears, internal bearing, epicyclic gear trains, gear units, methods of gear production, materials and heat treatment, inspection and calibration of gear teeth.

Basic Statistical Concepts

JOE KENNEDY ADAMS, *Assistant Professor of Psychology, Bryn Mawr College.* 6¼ x 9¼ *in.*, 304 *pp. Published by the McGraw-Hill Book Co.*, 330 W. 42 St., New York 36, N. Y. $5.50.

The book shows the reader the relation between mathematical theorems and applications, and covers the logic of statistical inference and the most frequently used mathematical models, both discrete and continuous, with numerous applications. Its purpose is twofold: to develop some basic statistical concepts, and to explain

(Continued on page 381)



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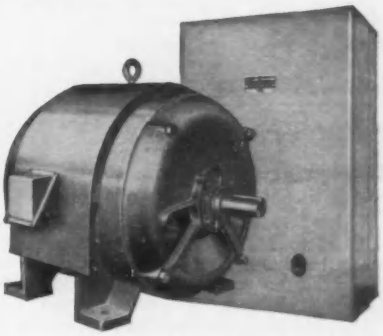
Why don't you investigate the possibilities for savings by using Wagner Increment Start Motors on your big jobs? Your nearby Wagner engineer will help you select the increment motor and starter combination that meets your requirements. Call the nearest of our 32 branches or write for Bulletins MU-128 and MU-195.



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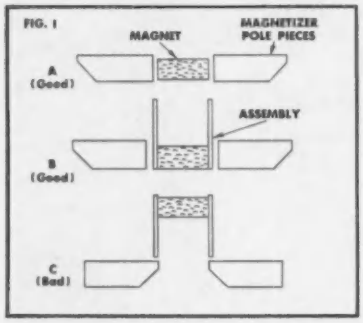
INDIANA
PERMANENT MAGNET
DESIGN INFORMATION

published for industrial and consumer
product engineers and designers

HOW TO MAGNETIZE PERMANENT MAGNETS



Magnetizing permanent magnets after assembly into the product offers several advantages. Higher field strengths are obtainable. The magnetic field produced in a loudspeaker, for example, using an Alnico V permanent magnet that has been magnetized after assembly, is about three times as great as the field obtained when the same magnet is magnetized before assembly.

The unmagnetized magnets are easier to handle and to assemble with other parts of the assembly. There is less contamination due to pick-up of magnetic particles.

Magnetizing after assembly is also advantageous in such applications as watt hour meters, polarized relays, and permanent magnet motors.

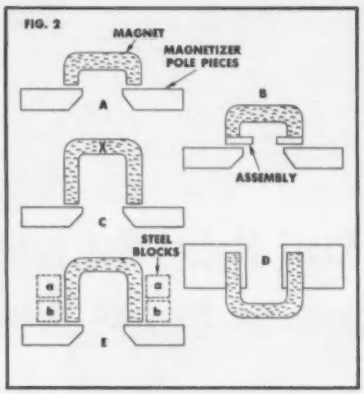
Using the Magnetizer

Most commonly used magnets are of simple bar or "U" shapes, which may be magnetized with an electromagnetic magnetizer in the user's plant.

Fig. 1-A shows how a bar magnet should be positioned between the magnetizer's pole pieces. The square ends of the pole pieces are used toward the gap. The space between the pole pieces is adjusted so the magnet can be easily inserted and removed. Normally, only one to two seconds are required to fully magnetize the magnet.

An assembly consisting of a bar-type magnet and soft-steel pole pieces should be placed with the magnet between the magnetizer pole pieces as shown in Fig. 1-B. Positioning the assembly as shown in Fig. 1-C will not fully saturate the magnet.

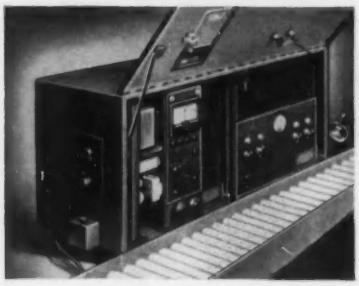
"U" shaped magnets and assemblies should be positioned as shown in Fig. 2, with the tapered ends of the magnetizer pole pieces used toward the gap. A meter or separator assembly would be placed on the magnetizer as shown in Fig. 2-B.



When a "U" shaped magnet is tall or larger than the generally accepted setting of the magnetizer, the field produced at point "X" (see Fig. 2-C) may not be sufficient to saturate the magnet. In this case there are two acceptable methods of magnetization. One is to place the magnet with its side on the pole pieces as shown in Fig. 2-D. This allows the yoke of the magnet to become magnetized. The magnet is then raised to the position in Fig. 2-C and again magnetized.

The other procedure is to stand the magnet on the magnetizer pole pieces with one or two steel blocks against each of its legs as shown in Fig. 2-E. The magnet (or assembly) is then magnetized three times: first, with both pairs of blocks in place; second, with blocks (a) removed; and third, with blocks (b) also removed.

For a complete discussion of how to magnetize permanent magnets by the electro-magnetic method, write for a copy of *Applied Magnetics*, Vol. 2, No. 3.



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AccuRay is a machine, made by Industrial Nucleonics Corp., that checks and controls the making of Chesterfields. One of the basic parts of this machine is a contact meter-relay, manufactured by Assembly Products, Inc. And the heart of this relay is an Indiana Hyflux Alnico V magnet!

Report on Indox I Ceramic Permanent Magnets

This recently published four-page technical bulletin, "Indox I Ceramic Permanent Magnets," suggests factors to be considered during design calculations, and discusses possibilities for new applications or improvements of existing ones.

Also discussed are some 30 representative sizes and shapes available in sample quantities for immediate shipment. Ask for price list and Catalog 15-C-2.

THE INDIANA STEEL PRODUCTS COMPANY
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WORLD'S LARGEST MANUFACTURER OF PERMANENT MAGNETS

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the language used in mathematical statistics, including the language of elementary calculus. The chapter on the calculus is included before the introduction of the continuous case, and a more extensive mathematical treatment will be found in the appendix.

An important chapter on statistical inference presents the concepts of expected sampling, distribution, testing of hypotheses, confidence intervals, and power of a test without introducing other than finite populations, so that the reader can best understand these concepts without being concerned with infinity, continuity, densit or the normal curve.

Metals Handbook, 1955 Supplement

8¼ x 11 *in.*, 208 *pp. Published by American Society for Metals, 7301 Euclid Ave., Cleveland 3, Ohio.* $6 *to nonmembers.*

The articles in the first group in this supplement pertain to closed-die forgings, helical steel springs, surface roughness, residual stresses and electroplated coatings. Those in the second group deal with the selection of sheet steel for formability, selection of material for press forming dies, selection of gray cast iron, stainless steel for chemical process industries and selection of aluminum alloy castings.

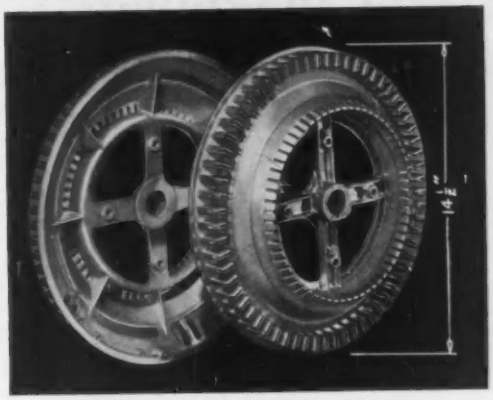
Design of Machine Elements

VIRGIL M. FAIRES, *Professor of Mechanical Engineering, North Carolina State College,* 6¼ x 9¼ *in.*, 550 *pp. Published by Macmillan Co., 60 Fifth Ave., New York 11, N. Y.* $10.

This volume presents and discusses the elements of machine design in all important aspects — from those phases of the subject employing basic strength of materials theory, to more advanced topics such as creative design, metallurgy and the application of statistics.

Faires incorporates a number of new features in this edition that should be helpful to the man on the job, as well as to the student engineer. He offers new design information for nearly every machine element, and an expanded treatment of two important subjects:

(Continued on page 383)



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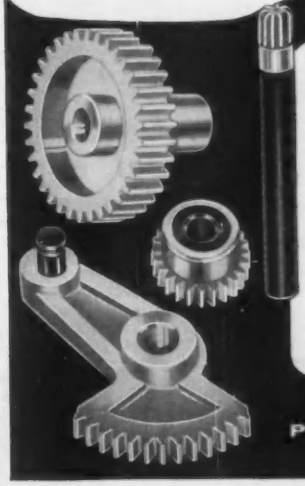

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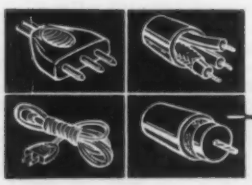

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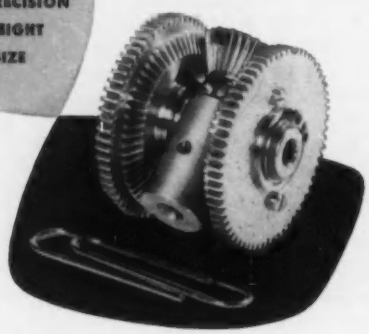

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variable stresses and fatigue, and the mechanical properties of materials. He has replaced Howarth's charts obtained from graphical solutions of Reynold's equation with charts obtained from analytic solution. An explanation of the fundamentals of roller bearings is included.

The book repeatedly considers endurance strength for the various machine elements, stresses throughout the statistical nature of engineering data, and develops the newer aspects of design. A large number of worked-out examples help to clarify the text.

Failure of Machine Parts—Prevention and Cure

Edited by RUNE EVALDSON, *Assoc. Professor and* CHARLES LIPSON, *Lecturer, Dept. of Mechanical and Industrial Engineering, University of Michigan. 11 x 8½ in., 136 pp. Published by Dept. of Mechanical and Industrial Engineering, University of Michigan, Ann Arbor, Mich. $10.*

The twelve lectures summarized in this volume were presented at an intensive summer course at the College of Engineering of the University of Michigan. Ten different lecturers, eight from industry and two from the college faculty, cooperated in presenting an overall picture of past failure. The four major subdivisions of subject matter included; How and Why Machine Parts Fail, Role of Design and Development in Prevention of Failure, Treatment of Specific Problem Areas, and Interpretation of Failures.

Mechanism

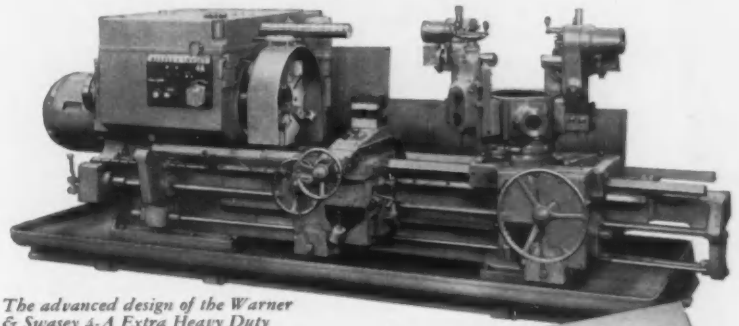
JOSEPH STILES BEGGS, *Member of Technical Staff, Hughes Aircraft Co. 9¼ x 6¼ in., 418 pp. Published by McGraw-Hill Publishing Co., Inc., 330 W. 42nd St., New York 36, N. Y. $6.50.*

This book, the first of the new "Series in Mechanical Engineering," was written for an advanced kinematics course at the University of California. It is both a reference book for the analysis of mechanisms and a source of mechanical movements.

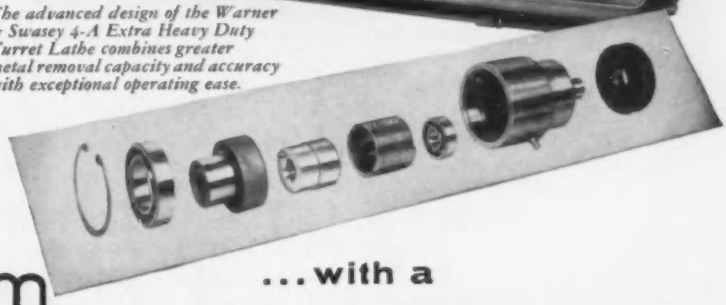
The book begins by pointing out the interrelation between selecting a

(Continued on page 385)

Here's how WARNER & SWASEY **controls coolant pump**



The advanced design of the Warner & Swasey 4-A Extra Heavy Duty Turret Lathe combines greater metal removal capacity and accuracy with exceptional operating ease.



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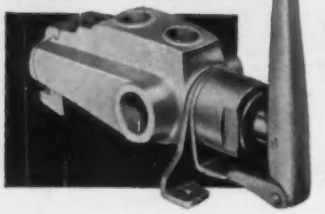
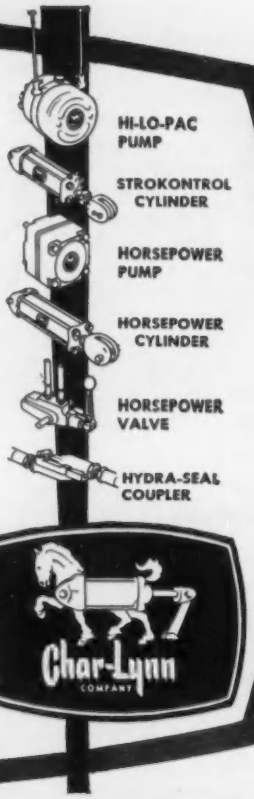
NEW

Char-Lynn HOLDKONTROL VALVE



MATERIAL: Die Cast Aluminum alloy body. Hardened steel valve spool.
CAPACITY: To 12 gpm. Built-in pressure relief, factory set
OIL PORTS: ¾" NPT inlet and return. ½" NPT cylinder ports.
MOUNTING: 3 points with ¼" bolts. Any position for operator's convenience. Reversible mounting foot. 360° handle positioning.
SYSTEMS: Convertible to control single or double acting systems.
FEATURE: **HOLDKONTROL** returns valve to neutral position when cylinder reaches end of stroke. Adjustment eliminates **HOLDKONTROL** if desired. Spring return to center. ¼" lands seal cylinder ports in center position.
WEIGHT: Five pounds shipping weight.



The Char-Lynn Holdkontrol Valve is a general purpose valve for agricultural and industrial applications. It offers a combination of many features —all of which have never before been offered in a single valve. Built-in **HOLDKONTROL.** This frees the operator from holding the valve in an operating position. The valve can be returned manually to neutral, or it will return by itself when the pressure exceeds the relief valve setting. Modern industrial design . . . Envelope completely encloses and protects functional parts. Built to withstand surge pressures above 5000 psi.

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mechanical movement and designing the members. The classical vector equations of relative motion are used to analyze mechanism of varying degrees of complexity. By use of descriptive geometry, these vector equations are applied to the solution of three-dimensional problems.

Subsequent chapters discuss the synthesis of gear tooth curves, efficiency of planetary gears; cams; rotary drives; linkages; tension and flexual links; compression links-fluids; computing mechanisms; control of mechanisms; kinematics of geometrical optics; precision; accuracy and combinations in mechanisms. A special chapter deals with Newtonian mechanics of rigid bodies, using vector notation. The final chapter is a repertory of mechanism for designers.

Knife-Edge Bearings

P. J. GEARY, *British Scientific Instrument Research Assoc.* 9½ x 6 in., 61 pp. *Published by British Scientific Instrument Research Assoc., South Hill, Chislehurst, Kent, England.* $1.50.

This is the second of a series of bibliographical surveys of instrument parts. The first was on flexure devices (see Product Engineering, Sept. 1955). The main contents of this booklet are an introduction to the subject of knife-edge bearings and a bibliography of 166 references.

The introduction deals with the different aspects of knife-edge bearings under appropriate headings. It is chiefly based on the information contained in, and constitutes a guide to literature cited in bibliography.

The bibliography, which covers the period 1900 to date, is in three parts:

1. Texts which can be considered as major contributions to the subject of knife-edge bearings taken as a whole. These are designated the 'principal texts' and are abstracted at greater length than the other material.
2. Other relevant texts, most of which contain useful or even important information about particular aspects of knife-edge bearings but which do not appear to warrant being classed as major contributions. They are termed "secondary references".
3. Likely-looking texts which there was no opportunity to study before preparation of this booklet.

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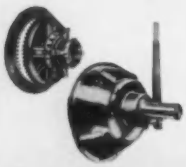

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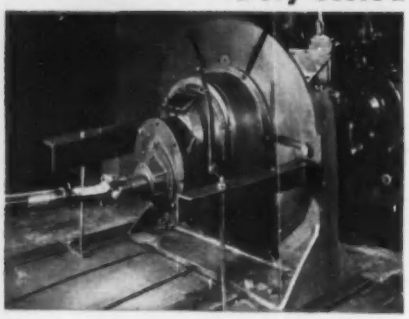

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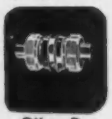

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OUR READERS SAY . . . . . .

Letters should be addressed to the Editor, *Product Engineering*, 330 W. 42 St., New York 36, N. Y.

Reference Book Sheets

To the Editor:

We have been using here at IBM for some time a set of four reference book sheets from your publication. We have no idea when this appeared in *Product Engineering*, but it is listed as "Fourth Series" and consists of four sheets on the subject "Length of Material for 90 Deg Forms" by J. K. Olsen, formerly Chief Draftsman, Stewart Warner Co. We are using the data sheet on which Table I appears and three tabular sheets for "Developed Length in Inches", designated by Roman numerals I, II, and III.

We contemplate preparing a manufacturing standards bulletin on this subject for general use in our organization. Our original photostatic copies of these reference sheets are in such poor shape that we can't be sure of the details. If you can furnish us with a reprint, we would greatly appreciate it. If it will be necessary to photostat the original, we will be glad, of course, to stand the expense of doing this. —JOHN B. SCHAFER
Endicott, N. Y.

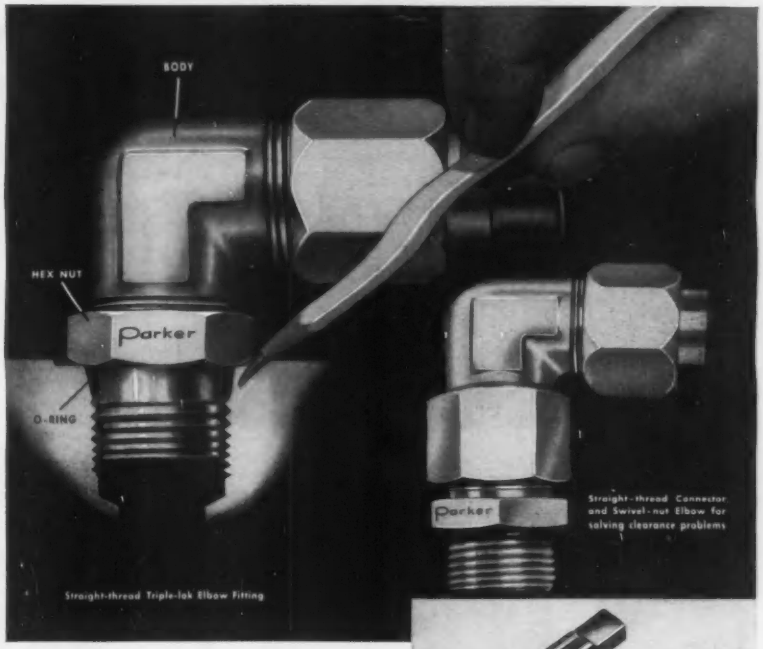
Ed.—The Reference Book Sheet in which you are interested originally appeared in the Dec. 1935 and Jan. 1936 issues of Product Engineering. They were later reprinted again in the Reference Book Sheet booklet to which you refer. Photostats of these four pages are available at 40 cents per page.

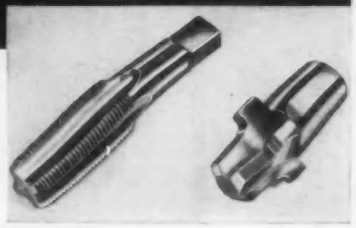
Product Development

To the Editor:

I am a member of the Post Graduate School of Engineering Production at the University of Birmingham, England, and am engaged in a detailed research of product development or-

(Continued on page 389)





Precision thread-tapping and counterboring tools for making accurate *straight*-thread boss (to receive these new Parker *straight*-thread fittings) are now available with machining drawings from Parker.

New Parker *straight*-thread fittings solve your leakage problems

Now you can forget about high-pressure hydraulic problems resulting from tapered pipe threads. Forget about leakage . . . about the danger of cracking or distorting valve bodies by over-tightening the fittings . . . about damaged threads from over-tightening to obtain proper positioning. Forget about messy pipe "dope".

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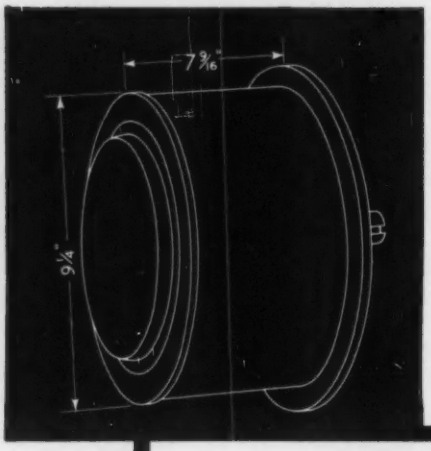

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ganization. After making a study of the literature on product development, it is apparent that very little has been written on the subject of its organization. I was, however, very interested in the articles published in *Product Engineering* recently and am therefore taking the liberty of writing to you in the hope that you may be able to give me some help in this matter.

I was particularly interested in the article in the September 1955 issue written by Mr. R. R. Allen of the Bennett Pump Div. of John Wood Co., on the particular method adopted in his firm. This treatment of the subject, in rather more detail, is just the kind of information which I am seeking. In my report I aim to show how the research, sales, engineering and production aspects can be most effectively co-ordinated to achieve rapid and efficient results.

I appreciate that in your capacity as editor private communications concerning published articles are not usually undertaken, but I am writing in the hope that you may be able to put me in touch with companies who have such systems in operation, particularly in the light engineering industry.

—N. B. HARVEY
Great Barr, Birmingham 22A
England

Ed.—While we were able to send Mr. Harvey the names and addresses of a few possible sources of assistance, we felt that possibly other readers of *Product Engineering* might like to lend a hand. If you care to write Mr. Harvey, we suggest that you do so

Previous Issues of Handbook

To the Editor:

We have only this year begun to subscribe to *Product Engineering*. The Annual Handbook of Product Design has already proved very valuable, and we would like to obtain the previous issues.

—WILLIAM MCHUGH
Chicago, Ill.

Ed.—We are unable to supply you with copies of the 1954 and 1953 Handbooks. Our supply of these handbooks has been completely sold out for some time.

We are listing below several com-

(Continued on page 391)

• SINCE 1925 • in the application, design and mfg. of pumps — separators — hydraulic accessories

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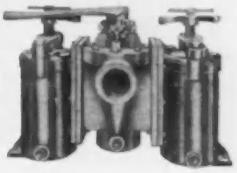

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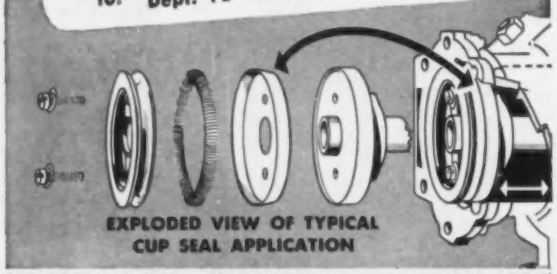

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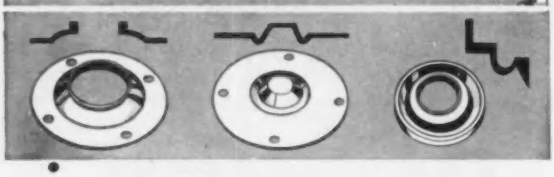

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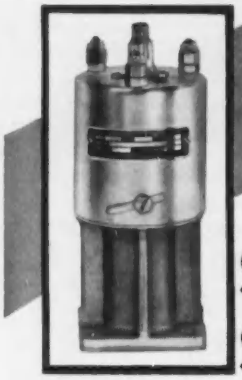

3 element

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Design and Foundry Practice

To the Editor:

A brochure issued by Hamilton Foundry & Machine Co., Hamilton, Ohio, and entitled "How Design Is Affected By Foundry Practice" has reached the writer's desk. This seems to be a reprint from *Product Engineering*.

We feel this article would be helpful to our young engineers, draftsmen and methods people. We would like fifty copies of this article if they are available. —W. J. HALL
Cleveland, Ohio

Ed.—This article appeared in the Feb. 1950 issue. Unfortunately, since it is this old, all type and cuts used in this particular article have long since been destroyed and we have no way of making additional reprints.

Data Needed On Electroforming

To the Editor:

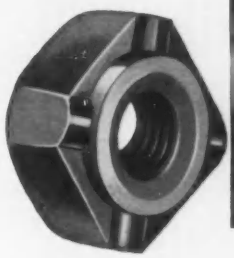
In your Aug. 1950 issue, page 145, you ran an article on electroforming. Would you be able to tell us whether there are any books available on this process? Can you give us some indication of companies other than Camin Laboratories, Inc., of Brooklyn, that are engaged in this business, either in supplying equipment to be used in electroforming or using this process on a job order basis?

C. W. BRABENDER
Minneapolis, Minn.

Ed.—The McGraw-Hill Book Co. has published a book on electroforming entitled, "Principles of Electroplating and Electrforming", by William Blum and George Hogaboom. This book summarizes modern methods of making electrodeposits on more than 40 different metals, alloys and plastics. Explanations of principles of electrochemistry and physics that underlie plating processes are given, as well as

(Continued on page 393)

SPEED UP THE FABRICATING, FASTENING AND ASSEMBLING OF METAL PARTS WITH



MIDLAND WELDING NUTS!

Midland Welding Nuts may be the answer to your dreams if you're in a business which fabricates, fastens, or assembles metal parts—OR, if you're a designer of products incorporating such parts.

Midland Welding Nuts are welded to the parts to be worked so that bolts can be turned into them speedily—without the need for any device to hold them in place.

They're just the ticket for those hard-to-get-at places. And they stay put—will not work loose or rattle.

Relied on by manufacturers the world over—and specified universally by product designers—Midland Welding Nuts will lower your assembly costs, speed up operations all along the line for you.

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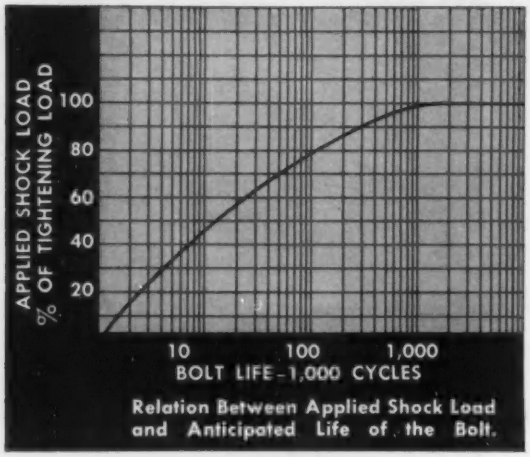

Relation Between Applied Shock Load and Anticipated Life of the Bolt.

factor to be considered, in application of finished hexagon nuts...

Figure 3, page 6 in the Engineering Section of our catalog, "Relation Between Applied Shock Load and the Anticipated Life of the Bolt," is just one of the several factors that are discussed, on pages 3, 4, 5 and 6, in the application of finished hexagon nuts, where highly stressed bolts of special material are required . . . Fourteen topics, concerning the technique in the manufacture and proper installation of our product are covered in this twenty-four page brochure—requests for this literature will be handled promptly . . . . . .

NATIONAL MACHINE PRODUCTS COMPANY

*Manufacturer of Standard and Special *12 Pointer and Hexagon Nuts..."Huglock" and "Marsden" locknuts.*

44253 Utica Rd., UTICA, Michigan

Light metals design tips

Present uses show how magnesium may solve your product design problems

This checklist shows how and why industry is using light-weight, heavy-duty magnesium, and it may suggest a way in which magnesium can serve you.

- Airborne equipment such as radar equipment, radios and accessories, tents, sleds, conveyors, shipping pallets and instrument cases; chassis, body structure, flooring and axle and brake assemblies in truck bodies and trailers; field glasses and binoculars, cameras, boats, canoes, toboggans and skis, high-jump and pole-vault cross bars, slide rules, musical instruments, portable sewing machines, dictating machines, lawn mowers, household appliances and baby strollers
  —because of its strength and lightness.
- Dockboards, hand trucks, portable gravity conveyors, loading ramps, shipping pallets, dollies, brick tongs and can forks in the field of materials handling
  —because of its light weight, fabricating versatility and ability to withstand rough usage.
- Manually handled tools and equipment such as foundry flasks and bottom boards, drills, saws, impact hammers, sanders, post hole borers, tree pruners, ladders and safety tongs
  —lightness reduces worker fatigue and increases efficiency. The rugged construction without weight penalty results in long life of the product during its use.
- Levels and masons tools
  —because of its lightness and good inherent resistance to the strong alkaline nature of mortar, cement, and plaster.
- Framework and bases for manufacturing machinery; parts that move rapidly during operation or reciprocating parts that change direction of motion many times a minute
  —lightness improves balance and reduces vibration, wear and noise and also overcomes starting inertia. The speed of textile looms has been increased as much as 50% by reduced weight.

Let us know if we can help you redesign your products to cash in on the many benefits of magnesium. Our engineering and fabricating facilities are at your disposal.

MAGNESIUM COMPANY OF AMERICA
LIGHT METALS FABRICATION DIVISION • EAST CHICAGO 27, IND.

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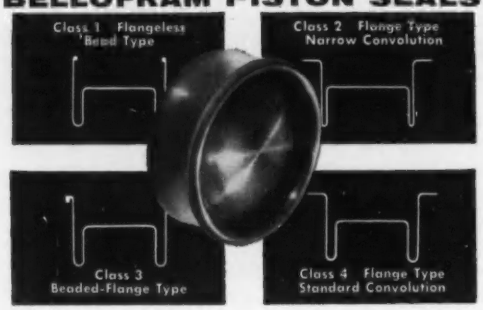
NOW THERE ARE 4 TYPES OF BELLOFRAM PISTON SEALS


Class 1 Flangeless Bead Type
Class 2 Flange Type Narrow Convolution
Class 3 Beaded-Flange Type
Class 4 Flange Type Standard Convolution

Bellofram long stroke, constant area diaphragms are now available in *four* designs, for efficient use as piston seals in countless types of pressure-sealed mechanisms. Class 1 permits design and manufacture of smaller, lighter, lower cost mechanisms. Class 2 is specially suited to high pressure applications and limited to sizes under 2½". Class 3 allows parting surfaces at flange joint to form a metal to metal joint. Class 4 is suitable for instruments and machines having natural parting surfaces between cylinder and mating metal surfaces.

Bellofram seals are available in any of 300 standard sizes; for 1" to 6" bores; in numerous elastomer-fabric combinations from Nitrile Rubber and Nylon to Silicone Rubber and Dacron. Choice is wide, design and operating advantages many. Outline your needs in confidence.

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recent developments in electrodeposition procedures and products. Tables show resistivities of solutions, hardness of electrodeposited metals, densities of commercial acids.

The only other company we know of doing this electroforming work on a job order basis is Bart Laboratories Company, Incorporated, at Main St., Belleville 9, N. J.

Source of Centrifugal Pump

To the Editor:

In your September issue there is an article entitled "Axial-Air-Gap Motors for Machine Tool Drives", by John Merriell. On page 135, Figure 7 (c), reference is made to a centrifugal pump using the axial-air-gap motor. I would like further information on this pump but I am unable to identify the manufacturer on the basis of the information given.—W. B. AULD
New York, N. Y.

Ed–The complete address of the firm which manufactures the pump pictured in our September issue is Leakproof Pump Division, Dolan Steel Company, 597 Hollister Ave., Bridgeport, Conn.

Indexing and the Handbook

To the Editor:

I like to work with your Handbook, but may I suggest an improvement for the next issue.

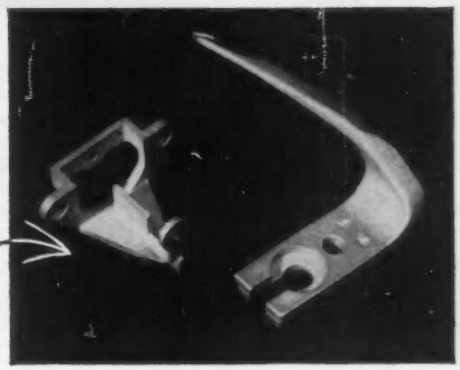
If I am searching for a paper published in *Product Engineering* on a special subject, I lose much time looking in the old issues until I locate the right one. Could you repeat in the handbook a resume of the subjects published in each issue of *Product Engineering*?

—JEAN-LOUIS TREYVAUD
Geneva, Switzerland

Ed.–Each year, in our December issue, a complete index appears of all articles which have appeared in the twelve issues during the year, plus the current Handbook. As you will note from the enclosed copy of our 1954 index, a detailed breakdown and cross reference of articles is given. We believe you will agree it is not practical to repeat this material in the Handbook.

If you've been thinking of investment castings like this

think of them also like this

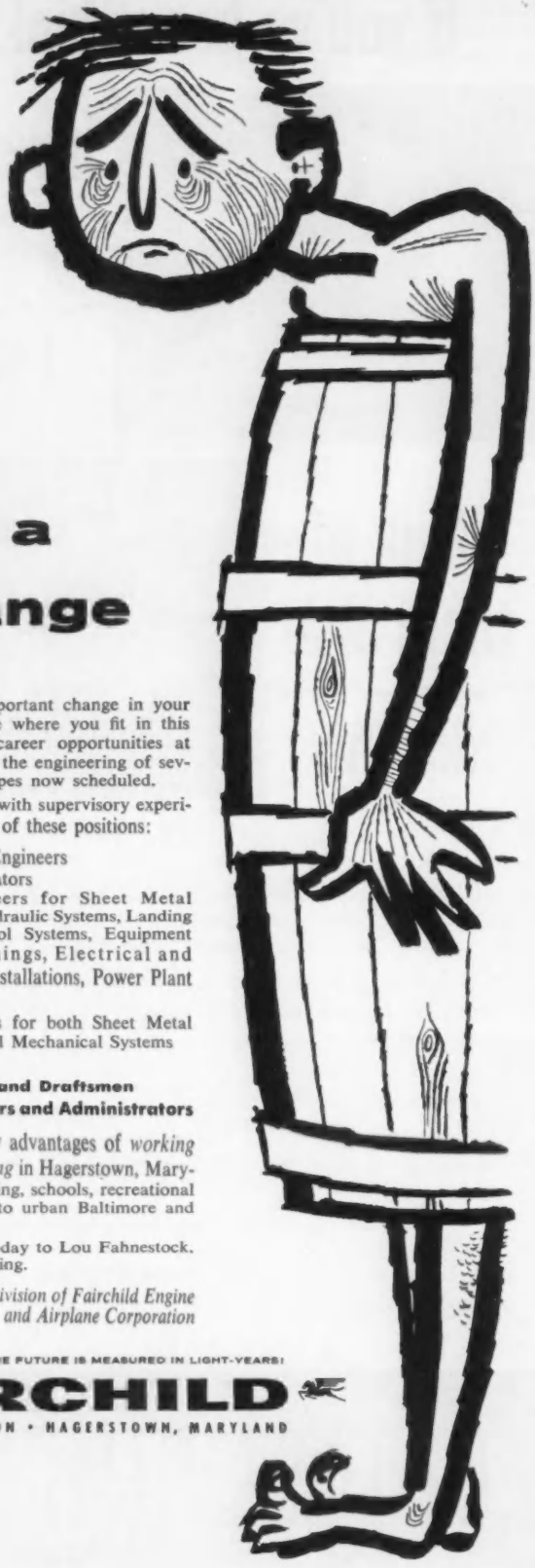


● The investment casting process is, of course, especially suited for complicated parts like this impeller. We pour hundreds of these "assemblies", which could not be produced by any other means. It isn't surprising, therefore, if a designer thinks only in terms of such impossible-to-machine parts.

Actually, Precision Metalsmiths cast hundreds of parts that seem quite simple in shape. But when you get to figuring the cost of blanking, forming, machining and finishing that is eliminated in the two castings pictured here, you understand. That knitting needle, for example, needs only to be polished before it's ready for work.

Why not look over some of your drawings and let us check your costs? The book, "Pour Yourself an Assembly", describes many of these parts. For a copy, write Precision Metalsmiths, Inc., 1079 East 200th Street, Cleveland 17, Ohio.

pour yourself an assembly with
PRECISION METALSMITHS INC.
INVESTMENT CASTINGS



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PRESS PREVIEWS

Jones & Laughlin Ups Improvement Expenditures

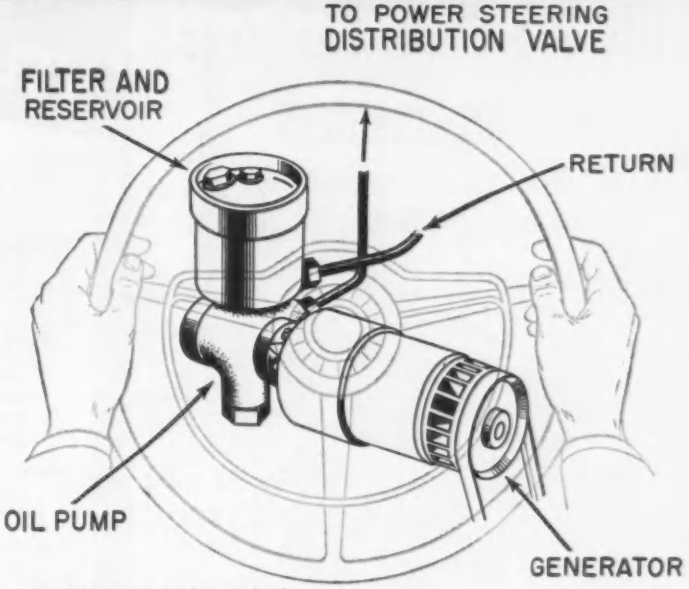
Jones & Laughlin Steel Corporation is stepping up its expansion program sharply, increasing its annual ingot capacity over 700,000 tons, and bringing expenditures to over 250 million dollars for improvement and expansion projects in the period 1955-58. The Corporation had previously announced that it would spend $135 million during the two-year period 1955-56 on improvements and expansion. The new plans for the four-year period through 1958 adds over $115 million to the original total. Present annual ingot capacity is approximately 6,200,000 tons. The new program will expand ingot capacity at the Cleveland Works by about 400,000 tons a year and at Aliquippa Works by approximately 300,000 tons a year.

The increase at Cleveland will be accomplished by improvements in the present open hearth facilities at the Works and by the addition of two new electric furnaces. Changes and improvements scheduled to be made in the processing and finishing units will more than double the present Cleveland Works capacity for the production of cold rolled sheets, while greatly increasing the efficiency of the processing and finishing units for both hot rolled and cold rolled sheets. Major new facilities at this Works, in addition to the two new electric furnaces, will include a blooming mill, additional soaking pits, a reversing roughing mill, a continuous pickler, a four-stand tandem cold-reducing mill, additional annealing, tempering, and shearing facilities and a processing line for hot rolled products. This is the largest improvement program approved for the Cleveland Works since its acquisition by Jones & Laughlin in 1942.

At Aliquippa Works, two oxygen blown converters–the latest development in steelmaking processes–will be installed as an additional part of the large program already going forward at the Beaver County (Pa.) plant. Jones

(Continued on page 397)

FILTER FORUM

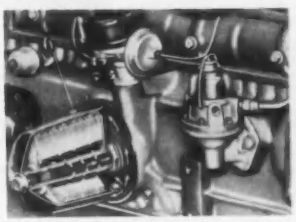


Automobile power-steering mechanism uses the filter case as a reservoir for the hydraulic oil supply.

Question:

What do you gain by including filters in original designs?

When installed equipment will not operate satisfactorily without filtration . . . or when cost savings and improved performance seem possible . . . filters can be added as an afterthought. But will foresight at the *planning* stage pay off in extra benefits?



Oil filter pad-mounted on side of engine crankcase.

PUROLATOR

FIRST in the field of filtering

Answer:

Economy, space, accessibility, better performance

Although it is certainly good engineering practice to put in a filter as soon as the need shows up, the benefits of anticipating that need are considerable:

1. A preplanned filter installation can cost less through simplification of required connections; through partial or total elimination of the filter case; or through utilization of the filter case for dual functions as in the example in our illustration.
2. Economical use of space and the job of "fitting things in" is more productive of good design in the plans stage.
3. Preplanning provides accessibility for servicing the filter and reaching other parts of the unit which might be blocked by an on-the-job filter installation.
4. Operating characteristics, i.e., the problem of pressure drop vs. flow characteristics can be balanced more effectively in the design phase.

MAIL COUPON FOR DESIGN INFORMATION

Dept. D9-229, Purolator Products, Inc., 970 New Brunswick Ave., Rahway, N. J.

Please send me the following filter information:

_____ Purolator's new "Filtration Manual for Designers".
I'm enclosing 25¢ to cover postage and handling.

_____ Enclosed is a description of our filter problem. How should we solve it?

NAME _____ TITLE _____

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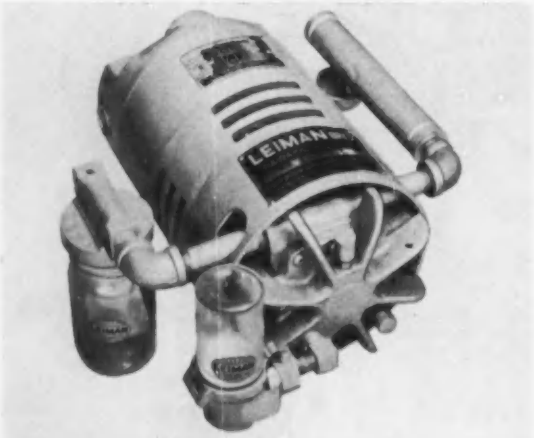

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- We have developed many new materials —synthetic rubber, fibre, asbestos and other combinations, several manufactured by the "beater mix" process. We have the right gasket for your particular problem.
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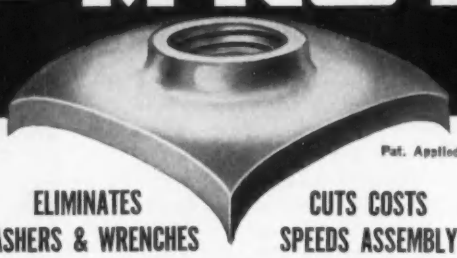
P-M NUT



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High-quality, low-cost nut is made of spring-tempered high carbon steel. Has cut threads and a flange with turned-down corners which bite into material to which applied. Spring flange is deflected during tightening for vibration-proof assembly. Used by leading manufacturers. Available in sizes 6-32 thru 10-32. Other sizes in process.

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& Laughlin will be the second steel company in the U. S. to use the new, revolutionary oxygen converters. The Aliquippa plant, with its high ratio of pig iron to steel ingots, is in a favorable position to use the new steelmaking process. Improvements also will be made in the soaking pits at Aliquippa to handle larger tonnages of ingots. The Cleveland and Aliquippa programs are expected to be finished in 1957.

A new Pittsburgh Research Laboratory, costing over 1½ million dollars, was dedicated by Jones & Laughlin in October. The laboratory is said to contain the most modern equipment for handling research problems of a steel company.

The two laboratory buildings stand on a five-acre site overlooking the company's Pittsburgh Works.

The broad scope of research activity is serviced by equipment for physical testing, metallographic studies, X-ray diffraction, spectrographic analysis, and analytical chemistry. Investigative programs cover all phases of the company's operations from raw materials processing, iron and steelmaking production of finished steel products, organic chemical processing, and development of new instruments for automation and quality control. The laboratory also houses the administrative activities of the Research Division, a 3,500-volume library, accounting and purchasing offices, and a fully-equipped machine shop. The Laboratory has a total floor area of about 40,000 sq ft.

In the laboratory building, special movable metal partitions have been provided for subdividing various areas. All the utilities—gas, air, and water; AC and DC wiring—are run in racks inside the partitions and can be repaired or augmented by removing face panels.

Ford Continues Cleveland Expansion

Ford Motor Company has established in Cleveland its largest base of operations outside of the home offices and giant Rouge plant in Dearborn. Ford now has four large manufacturing plants, a parts depot and Ford and Lincoln-Mercury sales offices in Greater Cleveland. The manufactur-

(Continued on page 399)

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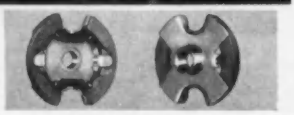
REWIND STARTER

Assures longer life and easier starting. Made principally of die-cast aluminum alloy, this starter is extremely light in weight—50% lighter than other types of starters. There is less pull because the starter engages after only ¼ inch of pull—instead of meshing teeth or pawls, the starter mounts over and engages on a regular rope starter pulley. The pull cord is fray-proof nylon, slim and compact yet will last for the lifetime of the equipment.

CENTRIFUGAL CLUTCH



This clutch is used on a variety of equipment which includes Lawn Mowers, Rotary Tillers, Garden Tractors, Chain Saws, etc. Approximately 80% of all Chain Saws are equipped with our clutch. This is the most rugged clutch application we know of. The Fairbanks-Morse Clutch is resistant to heat and shock which assures long life. The vital parts are tool steel. A wide range of engaging speeds are available because the springs are adjusted to fit the specific application.

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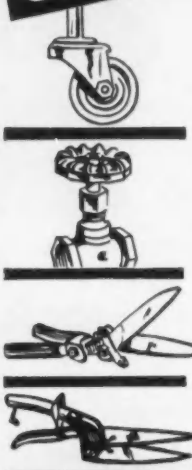
use this special, thin GRIPCO JAM NUT



to get a positive lock on bolts subjected to shearing stresses where the strength of a full nut is not required. The thin GRIPCO Jam Nut locks without the use of lock washers or other parts. The nut itself does the WHOLE job—so shorter bolts can be used. Applicable on such products as valve handles, casters, garden and pruning shears, hedge clippers, sickle bars, etc. GRIPCO JAM NUTS are manufactured in the new Unified Finish and Heavy Series (Hexagon). Furnished in standard full and jam dimensions, in steel, brass and aluminum. *Write for samples and full particulars*

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GRIP NUT COMPANY

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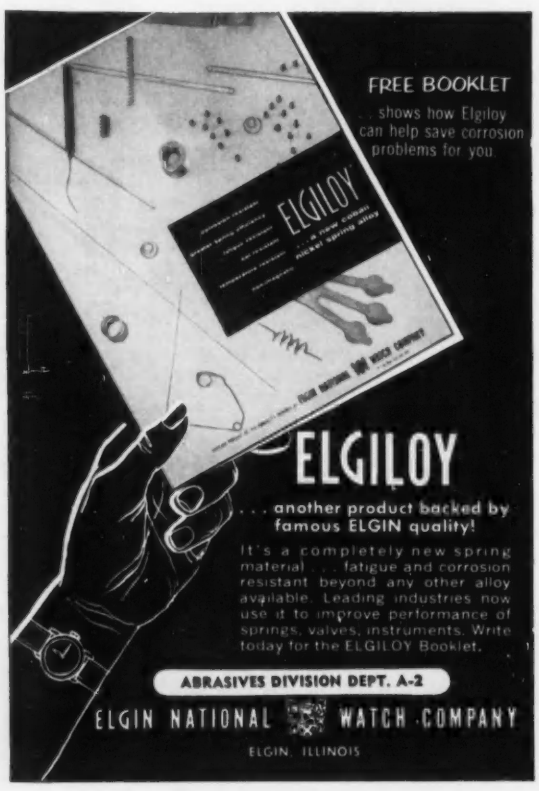
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Fixtures for inspection
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Locating
Trimming
Layout
Spotting Blocks
Vacuum Forms
Keller Patterns
Draw Dies
Hydropress Dies
Paint Masks
Prototype Parts
Spinning Chucks
Holding Fixtures
Lathe Fixtures
Milling Fixtures
Buffing Chucks
Core Box
Core Box Sections
Core Driers
Pattern Parts

Assembly Fixtures: welding—spot welding, arc welding, gas welding. Molds for casting other materials.

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ing facilities—a foundry, two engine plants and a stamping plant—and the parts depot have been constructed since 1950. The company now employs over 16,000 persons in Greater Cleveland with an estimated annual payroll in excess of 70 million dollars, with all operations under expansion to 1957.

The new stamping plant—claimed to be the most modern in the automotive industry—is producing body parts for Ford, Mercury and Lincoln passenger cars, using the latest techniques of automation, elaborate material handling devices and modern quality control methods. The giant plant is located in suburban Walton Hills, 14 miles southeast of downtown Cleveland. Over 3,800 are employed at the plant which occupies a 111-acre site and encompasses 1,334,000 sq ft of manufacturing floor space. A 215,000-sq ft addition is currently under construction at the south end of the plant, with completion expected early in 1956. Construction work began at the stamping plant October 16, 1953, and the first stamping was produced 10 months later.

Twenty-two major press lines with 107 large presses do the bulk of the work in the stamping plant, supported by hundreds of smaller presses, welding machines and tool and die equipment. A 35,000-ton storage area holds the sheet and coiled steel used in the presses. Approximately 80 per cent of the steel used in the plant is received in large coils weighing up to 30 tons. Giant 30-ton cranes feed the coils into automatic blankers where the steel is cut to size for the huge presses, ranging in weight from 20,000 to 900,000 pounds.

Automation devices set the heavy stampings into presses with pinpoint accuracy; reach into the presses to extract them, and speedily move them to the next operation. Each piece is automatically turned, twisted or inverted when necessary. Automation and presses are cycled by new drop-cam electric controls which send all units into action at the correct moment. Employes guide the stampings, adjusting pieces where necessary.

A completely staffed automation department conceives, designs, constructs, tests and maintains all automation in the plant, and is responsible for finding easier and more efficient

(Continued on page 400)

it's that simple!

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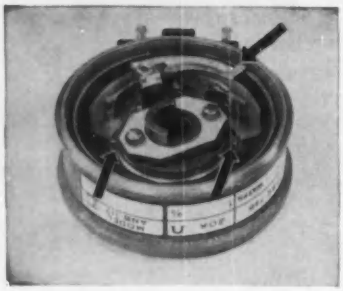

Arrows point to Paliney #7 contacts used in this Fairchild Type 746 Precision Potentiometer.

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Reliability of many precision electrical instruments depends upon accurate transmission of electrical signals between moving parts. The Potentiometer Division of the Fairchild Camera and Instrument Corporation has selected Ney Paliney #7* for use as wipers and sliders in their precision potentiometers because Paliney #7 provides the important advantages of a long life with excellent linearity and the ability to hold noise at a minimum.

Ney manufactures many other precious metal alloys which, like Paliney #7, have ideal electrical characteristics, high resistance to tarnish, and are unaffected by most industrial atmospheres. Ney Precious Metal Alloys have been fabricated into slip rings, wipers, brushes, commutator segments, contacts, and intricate component parts and are used in high precision instruments throughout industry. Should you have a contact problem, a call to the Ney Engineering Department will result in study and recommendations which will improve the output of your electrical or electronic instruments.

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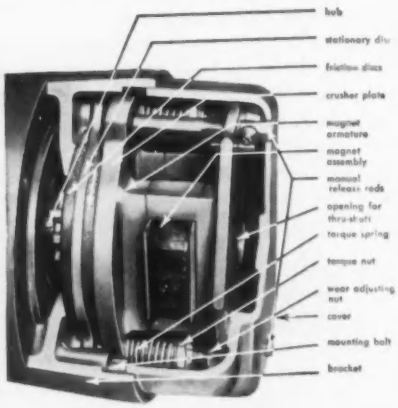

THRU-SHAFT DESIGN

While a Dings Brake accommodates the standard NEMA shaft extension, eliminating the necessity of using special shaft extensions, a simple modification of the cover converts the brake for Thru-Shaft applications. This facilitates direct coupling, use of hand cranks, tachometer, plugging switch, pulleys, etc.

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A SUBSIDIARY OF DINGS MAGNETIC SEPARATOR CO.

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DB156

methods of moving approximately 3,000 tons of cold-rolled steel through the plant daily. Well-equipped design, construction and repair areas are available for this function.

Automation also has been applied to the welding operations. Stampings from two or more lines are conveyed simultaneously into electric welding machines where they are joined into a finished body part. A series of welding operations are performed on the stampings which mounted on mobile fixtures slowly revolve in a circle.

An elaborate overhead conveyor network aids in moving stampings through production processes and to shipping docks. Industrial tow trucks and fork-lift trucks are used to handle stock in the more than 200,000 sq ft of storage space in the plant.

Hundreds of checking fixtures and gages located throughout production areas insure that only top quality stampings reach the shipping area, with a close check kept on all operations from the time steel is ordered until completed stampings are shipped. Quality control charts, graphs and other visual aids are utilized.

The new plant has basement scrap handling facilities; as scrap trimmings are cut off by the press dies they drop through chutes into mobile dollies which carry them to a giant baling press. Hydraulic pressure in the press compacts the trimmings into a tight bale, which then moves onto a conveyor and into a waiting freight car for resale to steel mills.

The main building, press basement, garage, pump and oil houses are all automatically sprinkled. Other fire protection measures include a specially constructed roof and two 250,000-gal water storage tanks. Ventilation and cooling temperatures during summer months is accomplished by a complete change of air every six minutes.

The new Cleveland Engine Plant No. 2 is located on a 147-acre tract of land that also embraces Ford's Cleveland Engine Plant No. 1 and Foundry. The new engine plant has 562,000 sq ft of manufacturing floor space and presently is producing Ford V-8 engines.

An expansion, now underway at the west end of the building, will increase the production area by approximately 300,000 sq ft. When the expansion is completed, six-cylinder engine produc-

(Continued on page 401)

tion, now in Engine Plant No. 1, will be moved to the new plant, which also will continue to produce V-8 engines.

Over 2100 persons currently are employed at the new plant. Employment is expected to increase to approximately 3000 when the expansion is completed. The plant's present annual payroll is nine million dollars.

Engine Plant No. 2 is an excellent example of the development of automation as a production technique in the automotive industry. The greatest single automation improvement was made in the drive unit. Hydraulic oil is the motivating power for all transfer mechanisms where air-actuated devices were previously used.

Engine assembly operations incorporate a conveyor line having ample storage space. Composed of 14 independent "power and free" units tied together like links in a chain, the new conveyor system makes it possible to continue production even though one segment of the line may be down for repairs. Engine blocks are suspended from overhead monorail tracks on steel arm carriers which move them through operations at a height convenient for the assemblers. The blocks can be rotated to any position or angle so that each surface of the engine is readily accessible. A maze of track switches honeycomb the system. The engine blocks are routed over the many available paths by small electric switch boxes. Located on the steel carrier arms, these adjustable electric contacts actuate the switches along the assembly line and route the engine.

In the assembly area is a large control panel with flashing red, orange and white lights and a multi-colored schematic drawing of the assembly area. The control panel gives supervisors a complete picture of what is happening the length of the more than mile-long engine assembly conveyor system. Located adjacent to the assembly area are 44 hot test stands on which each engine produced in the plant is tested. Only those engines which pass this critical 20-minute test are shipped to assembly plants for installation in customer automobiles.

A TelAutograph communication system is used to coordinate the delivery of proper sized piston and connecting rod assemblies to the cylinder block. This is the first installation of TelAutograph made by Ford Motor

(Continued on page 403)

WALES "Strippits"
can save up to 60% time,
BOOST PROFITS 25%
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If your company is concentrating on the economical redesign of current products to meet the increased competition of "post-Korea", you'll be interested in what others have found. In designing for less costly, just-as-effective substitutes for Vee, Cup and Flange packings, many design engineers have turned to the G-T Ring. They have found that, as a dynamic pressure seal (from 0 to 20,000 psi) for rod or piston applications, Palmetto G-T Ring can't be matched—for economy . . . for effectiveness! Here are some of its successful applications:

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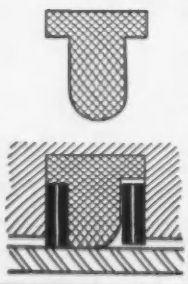
THE GIST OF THE G-T RING



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The Palmetto G-T Ring, unlike an "O"-Ring, will not twist and turn in the groove. The "T"-form prevents spiral failure in dynamic applications.

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Resilient "T"-section supported by non-extrusion rings on either side *makes extrusion impossible.* As pressure is applied non-extrusion rings are urged against wall, blocking path of extrusion.

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IF magnets can solve your tooling problem

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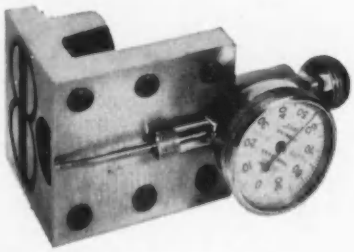

Cerro Alloys can fasten magnets without press fits, set screws, etc., as was successfully done by the manufacturer of the "Magic Tool & Die Checker". For dependable results insist on genuine Cerro Alloys.

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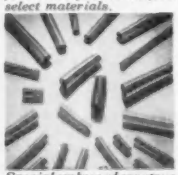

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Company for engine production. As a cylinder block reaches the beginning of the assembly line its dimensions are checked and transmitted via the Tel-Autograph to locations in the plant where engine components are selected to match the cylinder block dimensions. The components are placed on conveyors for delivery to engine assemblers and reach the assembly area shortly before the matching engine block.

Selective fitting of these components is one of the plant's many quality control measures. Over 1,000 mechanical and pneumatic gages, each designed to check specific dimensions or relationships for accuracy are used by the quality control department. Hundreds of charts are used to indicate the quality being produced by each machine at any given time. Dynamometer tests and critical tests regarding horsepower rating, fuel and oil consumption, durability and other items are performed in the interest of a quality product.

Numerous fire prevention devices have been engineered into Engine Plant No. 2. Giant smoke and heat venting hatches that open automatically, fire curtain boards, automatic sprinklers and a specially constructed roof are a few of the features designed to aid in preventing and fighting industrial fires.

Incandescent Lamp Efficiency Increased

General Electric has announced "the greatest single improvement in incandescent light bulb performance in 42 years," which is estimated to increase light output from 6 per cent for household bulbs to 15 per cent for higher wattage bulbs used in industrial and commercial lighting. Ultimately the benefit to American consumers in the form of increased light can amount to more than $100,000,000 annually, according to General Electric. Herman L. Weiss, general manager of G.E.'s Large Lamp Department, Cleveland, has announced immediate availability of the improved lamp in the 750- and 1000-watt sizes. Other sizes will be similarly improved within next few years, as rapidly as equipment is built and installed for mass production.

Vernet C. Kauffman, department

(Continued on page 405)

Before you jump into production

remember

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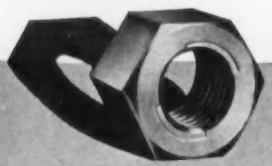

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manager of engineering, said the increased light output is achieved by the following steps: 1) Improving the tungsten filament by making basic design changes; 2) altering the mount structure, so that the filament is positioned lengthwise, or axially, in the bulb; and 3) substituting coiled-coil filaments for singly coiled filaments in lamps of 300 watts and larger.

Lamps of 300 watts or larger will have an increased light output over their lifetime of 15 per cent. The improved 750-watt bulb, for example, will produce an average of 21.6 lumens per watt of electricity consumed. This compares with an efficiency of 18.9 lumens per watt for present 750-watt bulbs. In the case of household sizes, which already have the benefits of coiled-coil filaments, the light output increase will amount to at least 6 per cent.

Axial positioning of the improved filament, the most dramatic visual change in the improved lamps, does two things to increase light output, Kauffman explained. First, it permits the filament to burn at higher temperatures without shortening the operating life. The hotter a filament burns, the more light it produces. Secondly, bulb blackening now concentrates in a smaller area, permitting more light to radiate out from bulb.

Bakelite Produces Film On Phenolic Molding

The Bakelite Company, Division of Union Carbon and Carbide, has prepared a technical film "Molding Phenolics", which describes the factors involved in the phenolic molding cycle. The film is said to bring together for the first time all the artisans, craftsmen and technicians who contribute to the production of a phenolic molded article.

Methods of designing, building, and finishing molds for general or specialized articles is outlined in the first portion of the film. Every basic phenolic molding process is outlined schematically and the advantages of each process are pointed out. The most important variables, temperature, pressure, and time, are discussed. Specialized problems such as mold release, inserts, undercuts, and machining are mentioned with special emphasis on

(Continued on page 407)

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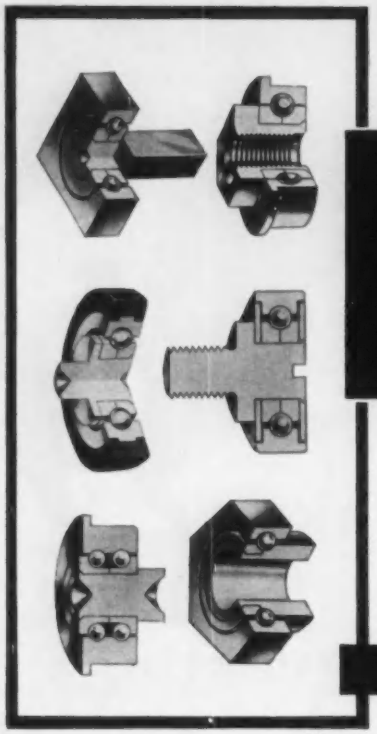

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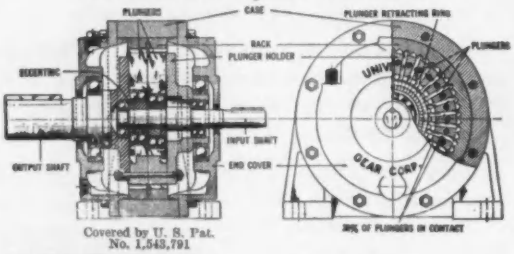

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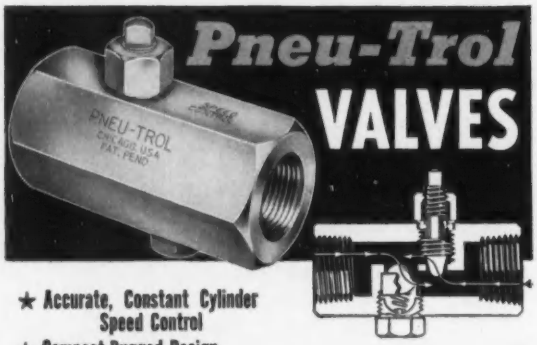

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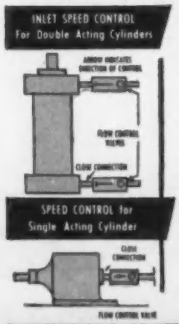

Pneu-Trol Speed Control Valves, are widely used in hundreds of control applications because they combine in a short, compact body, a tapered fine thread needle for extremely accurate air or oil flow control and a floating retro ball check, which permits full flow in the opposite direction. Retro ball floats in most sensitive position to its seat, requiring only a slight differential pressure to fully open or close it.

Needle design permits maximum flow capacity in the controlled direction. Metal to metal needle and ball seats insure long trouble-free service. Simple, practical "O" gland structure eliminates troublesome leaking. Valve bodies machined from hex brass or aluminum for 2000 psi working pressures; steel and stainless steel for 5000 psi. Made in 5 female pipe sizes—⅛" to ¾". ATTRACTIVE PRICES . . . IMMEDIATE DELIVERY.

Write for illustrated circular and prices.

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the latest techniques. Recognizing the trend in industry toward more efficient methods of production, information is offered on how automation may be adapted to the phenolic molding cycle.

A manual, accompanying the film, can be used as a starting point for questions and discussions after the film has been shown. This 16 mm film is twenty minutes long and is available for industrial group presentation from the Bakelite Co. Technical Film Library, 292 Madison Avenue, New York 17.

Ryerson Purchases Follansbee Plant

Joseph T. Ryerson & Son, Inc., steel warehousing subsidiary of Inland Steel Co., has made another expansion step in its New England operations. The company has purchased the property and inventory of the Wallingford, Conn. plant of the Follansbee Metals Corporation. The acquisition brings to seventeen the locations through which the company conducts its nation-wide steel distribution business. The plant is described as well situated to serve a territory formerly divided between the Boston and Jersey City plants. The buildings at Wallingford were constructed in 1954, with a warehouse area of more than 47,000 square feet, all heated and crane served.

The warehouse is equipped with large slitters and other equipment for processing steel, including friction and hack saws, angle and bar shears, and flame cutting equipment. The Wallingford plant and stocks will be "substantially enlarged to cover a more complete range of sizes and products and to provide facilities commensurate with the needs of this area," according to Charles Hardy, President of Ryerson.

Bogue Electric Opens New Canadian Plant

Bogue Electric of Canada, Ltd., has opened production and administrative headquarters in a new plant at Gloucester, near Ottawa, Ontario.

The new plant will give the Canadian firm important facilities for the production of motors and gen-

(Continued on page 409)

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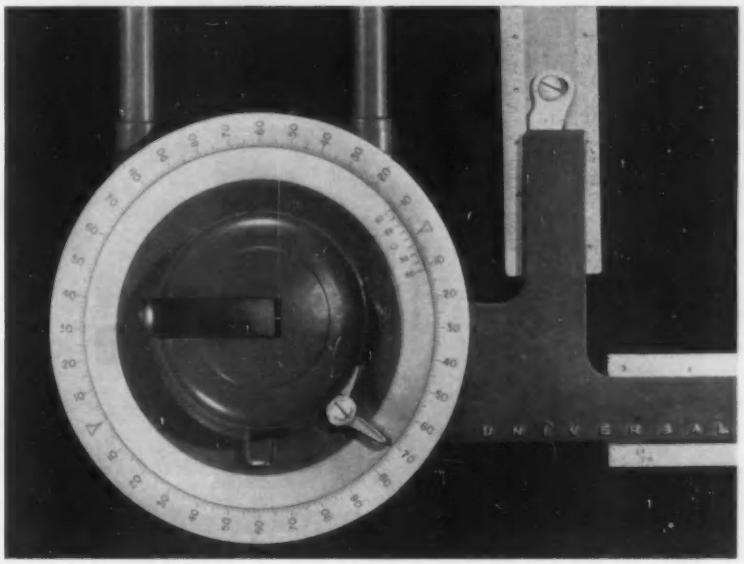
with Universal's Boardmaster...



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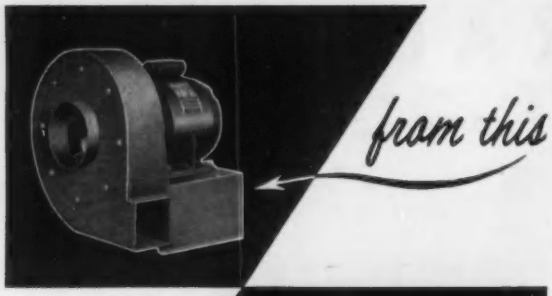

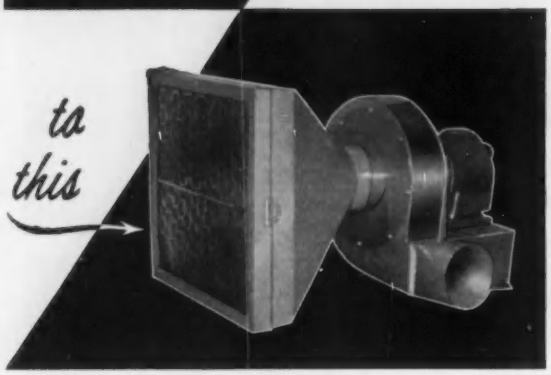

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Ask for Bulletin SDA-160.

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erators, power supplies, control systems and electronic components for industrial and military applications.

"With the Royal Canadian Air Force now engaged in the greatest peacetime build-up in its history, Bogue equipment specially designed to serve its needs—from tiny components for guided rockets and missiles to unique aircraft testing, servicing and starting equipment—will make important contributions to Canadian air power," Mr. Schinman, President of Bogue, said.

Other products to be manufactured at the new plant include water conditioning equipment, magnetic amplifiers, rectifiers, servo-systems, sonic tank gauging equipment and bearing temperature monitors.

Designed for a maximum of efficiency and ease of materials handling, the ultra-modern industrial structure covers approximately 80,000 sq ft under one roof. When the plant is in full production it will employ approximately 350 persons.

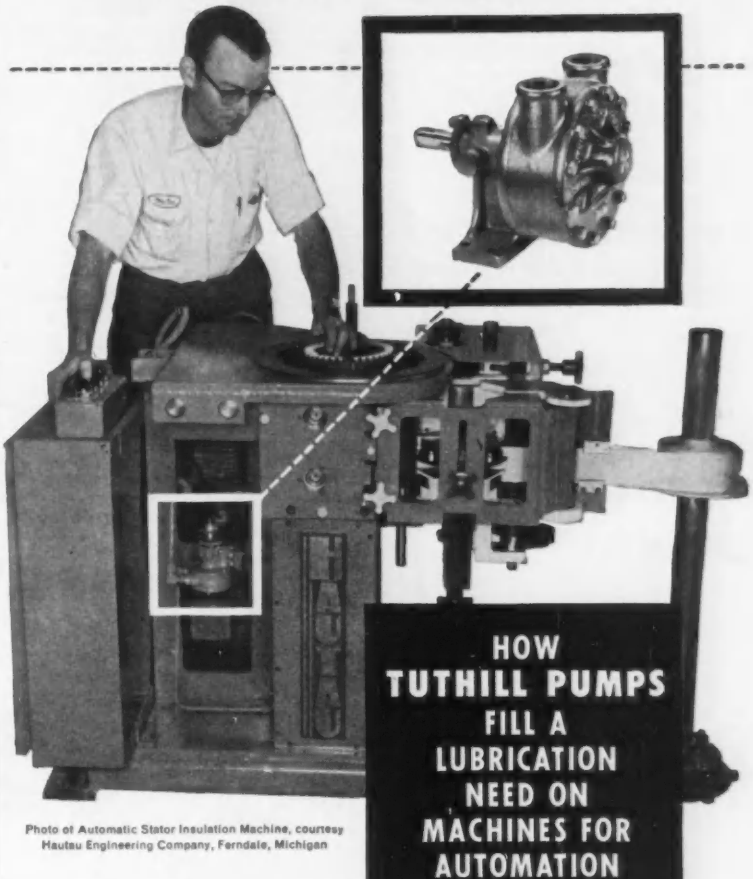
A. O. Smith Expands Heating Equipment Line

The A. O. Smith Corp., Milwaukee, Wisc., has announced plans to assume a fully competitive position in the home heating industry. A one million dollar two-year plant expansion program is scheduled for the company's heating and air conditioning products section, and the 1956 furnace and air conditioner lines will be increased by as many as sixty new models. Almost 200,000 sq ft of manufacturing space for furnaces and air conditioners will be added to the Kankakee, Ill., works.

By year end there will be eighty-two gas and oil fired models, ranging from 70,000 to 245,000 BTU/hr input ratings. The previous line consisted of three basic models, all with 100,000 Btu/hr ratings. A. O. Smith is reported to be the only furnace manufacturer offering ceramic-coated anti-corrosion protection on all models at no extra cost in 1956. Outstanding design features of the new furnace models include the mulitple radiator heat exchanger (formerly doughnut-shaped) and the optional Magic Heet modulation by which the gas flame burns higher or lower in direct pro-

(Continued on page 411)

KEEPS "Monkey-Wrenches" OUT OF GEARS!



HOW TUTHILL PUMPS FILL A LUBRICATION NEED ON MACHINES FOR AUTOMATION

Photo of Automatic Stator Insulation Machine, courtesy Hautau Engineering Company, Ferndale, Michigan

In developing this machine that automatically forms and inserts insulation for the stators of electric motors, Hautau engineers required a dependable pump for lubricating the various operating gears and indexing mechanism. For this vital service they selected the Tuthill Model C internal-gear rotary pump.

The performance characteristics of this positive displacement pump make it ideal for pressure lubrication. It holds its prime. Instantly delivers the capacity needed. Operates quietly. And it is built for long, uninterrupted service. Tuthill specializes in building pumps for the purpose. Whether your production calls for standard pumping units or special pumps for engineered applications in lubrication, coolant, hydraulic or liquid transfer service, it will pay you to submit your specifications for recommendations.

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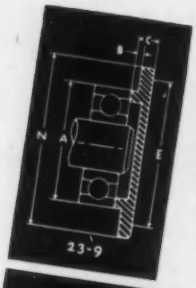
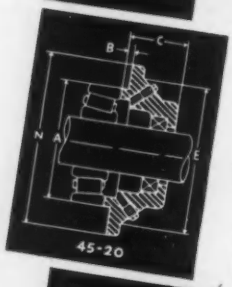
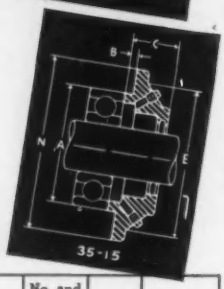
conserve time... materials and reduce "nuisance" set-ups with

B-A STANDARD BEARING COVERS







Description	"A" Bearing O.D.	"B" Depth Rabbet	"C"	"E" Bolt Circle	"N"	No. and Size Bolts	Shaft	O.D. Oil Seal
#23-9	2.2500	1/8"	7/16"	3"	LUG TYPE	4 3/8"	—	—
#45-20	5.0000	3/16"	2 1/4"	6"	7"	6 1/2"	2 1/8"	3.555
#35-25	6.2992	1/4"	2 1/16"	7 1/2"	8 3/4"	6 5/8"	3 1/16"	FELT 3/8" x 3/16"

B-A Standard Bearing Covers are available in 14 sizes, 12 types, 3 depths. They fit all standard size ball and roller bearings. Approved by all bearing manufacturers. Low unit cost in small or large quantities.

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portion to the temperature of the cold air returning to the system. The units are designed for compactness, with the standard Lo-Boy model only 38 in. high; no handles are on the unit exteriors, and a draft-diverter has been built-in. Selling price will be as much as 25 per cent lower than that of some previous models.

A new Year Round Air Conditioner model will be introduced in which the cooling unit is relocated from a horizontal position in the base to a vertical arrangement, to slightly widen but greatly lower the model. A new line of vertical cooling units in both air and water-cooled models and available in two, three and five tons sizes will be also introduced. These vertical cooling units will be adaptable to existing heating equipment, both Permaglas and others.

Electromet Adds Research Facilities

A new Chemical Engineering Building at Niagara Falls, N. Y., has been completed for the Electro Metallurgical Company, a Division of Union Carbide and Carbon Corporation. The building is one of ten which make up the Metals Research Laboratories of the company.

The company's research department was started in Niagara Falls in 1906, and in 1921 these facilities were moved to Long Island City, New York, where they remained until 1934 when the first building of the Metals Research Laboratories at Niagara Falls was completed. Activities have ranged from fundamental research in metal structures to pioneering new processes for the winning of metals of exceptional purity. Recent major developments at or near the production stage include processes for the production of extra low-carbon ferrochromium and the production of titanium sponge through the sodium reduction process. Simplex low-carbon ferrochrome is being produced at Marietta, Ohio, and production facilities for titanium sponge are now under construction at Ashtabula, Ohio.

The new building is a windowless structure with the exception of the office section, with side walls of precast concrete panels fastened in place on the bolted structural steel frame-

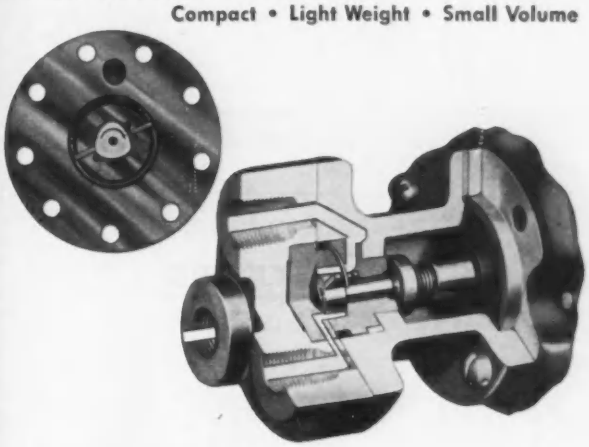
(Continued on page 413)

WELDON

FLUID METERING PUMPS

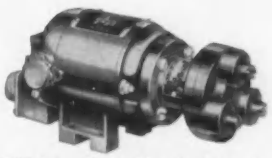
Positive Displacement Rotor Type. For Industrial Applications, Aircraft Anti-Icing and Aircraft Fuel.

Compact • Light Weight • Small Volume



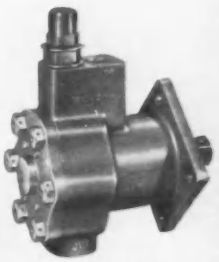
IT'S SO SIMPLE!

The rotation of the rotor draws the fluid in through two passages, filling the cavities formed by the three lobes of the rotor. This fluid is sealed within these small cavities until it is forced through the two outlet holes by the floating blades. The flow may be kept uniformly divided through two outlet ports, or may be combined internally for passage through a single port.



STYLE A—Single inlet double outlet type aircraft pump

STYLE C—Industrial pump



STYLE F—Engine driven fuel pump

Send for Weldon Manual and Catalog with detailed specifications and installation drawings.

THE WELDON TOOL COMPANY

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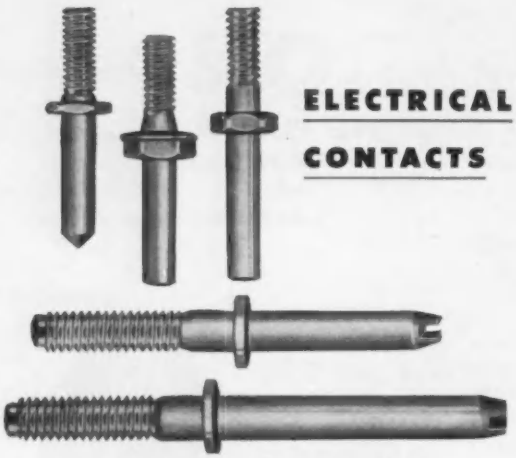

ELECTRICAL CONTACTS

ADJUSTING SCREWS

NOTE: LEFT-HAND THREADS

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One interesting feature of several of the items above is that they are roll-threaded on the *short* end — a neat trick that called out some ingenuity on the part of ELCO shop people. ELCO facilities also include an Engineering Service that will help you design — or re-design — your special screws and similar pieces for *lowest-cost* manufacture. *Always consult your ELCO representative.*

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"ELCO SCREWS ARE GOOD SCREWS . . . ASK A MAN WHO HAS USED THEM"

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For Extra Long Life
at Full Rated Load
Maximum Service
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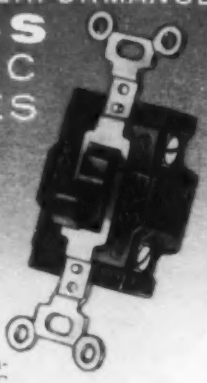

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The expanding ANGLgear line — now including 1/3, 1 and 3 hp units available with 1-1 or 2-1 gear ratio and with either 2 or 3-shaft extensions — enjoys wide acceptance in many fields. It's sold only through your local distributor. See our literature in the product design section of Sweet's Catalog.

AIRBORNE

ACCESSORIES CORPORATION

HILLSIDE 5, NEW JERSEY

work. The panels are sandwiches, 10-ft wide and of varying height, consisting of two slabs of reinforced concrete with insulating material between them. The concrete panel construction simplifies future expansion since the panels can be removed and replaced after the building is extended.

The building layout comprises a high bay with approximately 7000 sq ft of floor space and a free height of 40 ft, adjoined by an air conditioned two-story section consisting of module laboratories on the first floor and offices on the second floor. The high bay is served by a 10-ton, cab-operated crane and has a 10-ft wide balcony along two walls. The easily removable floor plates of the balcony facilitate the erection and use of tall equipment.

The high bay permits pre-pilot plant and pilot plant testing of processes worked out in the adjacent module laboratories. A main exhaust system serving the high bay provides periodic take-offs for exhausting process equipment. Main access to the high bay section is provided by two vertical-lift doors. In the event of an accidental release of noxious gases, an emergency switch will open these two doors and simultaneously start the emergency fans in four roof ventilators.

For maximum flexibility of arrangement, particularly with regard to services, the high bay section contains two rows of utility islands. Each row comprises six islands spaced at 20-ft intervals, with all services brought to the islands in trenches with removable concrete slab covers. Any or all of the islands may be removed to provide unobstructed floor space. A heavy reinforced concrete floor eliminates the need for providing special foundations for any piece of equipment. Whenever possible, unitized equipment which may be placed near and connected to a utility island will be used.

The module design of the laboratories also permits flexible arrangement. Removable partitions make it possible to devote an entire laboratory to research equipment or to provide partitioned office space as needed. It is also possible to combine two or more laboratories when a larger area is required. Each laboratory has a hood and multiple-purpose bench space connected to independent systems for the usual services plus distilled water. All working surfaces in the laboratories

(Continued on page 415)

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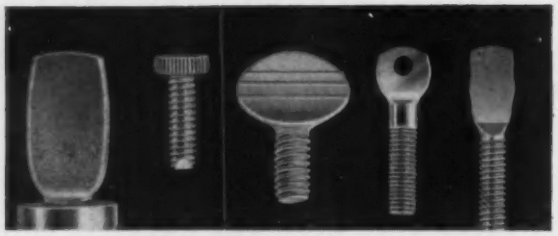

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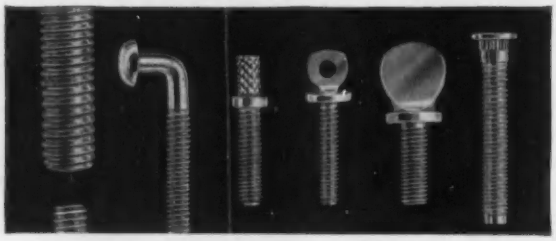
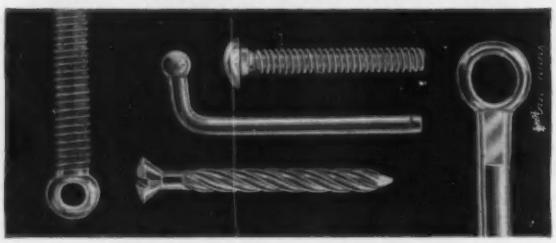


FOR PARTS LIKE THESE—AND



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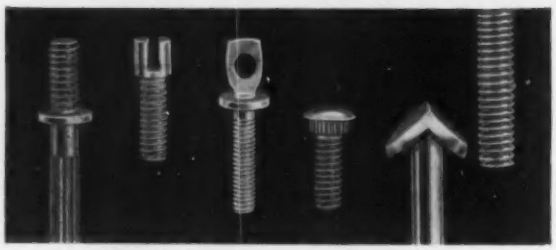

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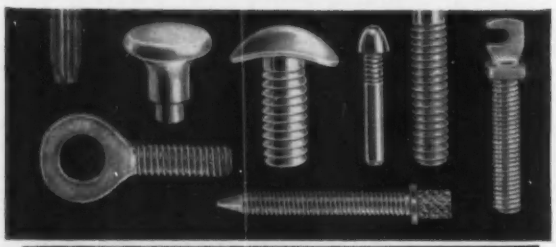

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LOngacre 4-3000

ADVANCE *builds 'em for heavy loads and long service!*

Cramped quarters don't cramp the style of ADVANCE midgets and miniatures. You can use them on loads up to 5 amperes continuously... and at three times their rating intermittently—with complete safety. They'll resist shock and vibration... stand up under temperature extremes. You'll find them readily adaptable to any mounting need... any type of duty. Here are a few examples:

"TINY MITE"

MM & MP SERIES

This ultra-small d-c relay occupies less than ½ cu. in. mounting space! It's stable under vibration and shock ...plated to prevent corrosion. Operate time is 5 milliseconds. Contact rating: .5 amp. or 1 amp.

MINIATURE TELEPHONE TYPE

TQ SERIES

Only .94 cu. inches in size, yet this relay carries 5-amp. loads in any combination up to 4 PDT. Mechanically secured throughout, it's extremely efficient. No gassing or bubbling. Withstands 10G vibration. Temperature range: −55° to +125° C.

Hermetic enclosures on these types are impervious to varying climatic conditions... are sealed and carefully checked against leakage.

Write for literature on any of the above series, or the complete ADVANCE line.

ADVANCE ELECTRIC AND RELAY CO.

An Elgin National Watch Company Affiliate

2435-M NORTH NAOMI STREET
BURBANK, CALIFORNIA

Sales Representatives in Principal Cities of U.S. and Canada

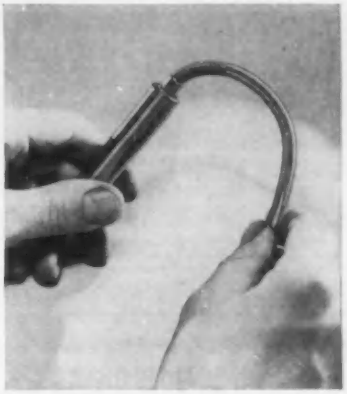
are of soapstone. The module laboratories are used either as research laboratories or control laboratories on pilot operations being conducted in the high bay section.

The building is equipped with a variety of special electric furnaces, all designed and built at the Laboratories. These furnaces permit such chemical reactions as carbiding, hydriding, nitriding, and sulphiding from a gram scale up to a 100-lb scale. Two controlled-atmosphere or high vacuum furnaces or original design provide temperatures of 1200 deg C and 1500 deg C, respectively. Other equipment includes a 50-kw high-frequency induction furnace, vacuum and inert gas arc-melting furnaces, a 500-ton compacting press and a foil mill capable of reducing a 2 by 6 in. slab to 1 mil foil.

Meanwhile, construction of the first titanium sponge plant in the United States utilizing the sodium reduction process is proceeding at Ashtabula, Ohio. For the past year construction crews have been transforming the 100-acre site into the new plant which will mark the entry of the Electro Metallurgical Company into titanium sponge production. The outer shells of the two furnace buildings are rapidly nearing completion, and the reactors, in which the sodium reduction process takes place, are being installed. The steel framework has been completed on the process and shipping building. When completed, the plant will produce 7,500 tons of titanium sponge per year. Electromet's process was developed in the Company's Metals Research Laboratories and produces titanium sponge by reducing titanium tetrachloride with sodium. Production at the new plant is expected to start in the third quarter of 1956.

Errata

The caption over the picture on page 140 of the January number reads, ". . . . serving both East and West Germany." This is incorrect. The German Physical-Technical Federal Institute serves all of West Germany and the Western Sector of Berlin. It does not serve Eastern Germany.



New spring stress reliever increases operating life

CHROMALOX
Electric
CARTRIDGE HEATERS

On applications which require repetitive flexing action, you can now obtain Chromalox Electric Cartridge Heaters equipped with an ingenious high tensile spring—which protects the lead wire against premature breakage.

The spring—which is mechanically locked to the cartridge heater and is not affected by heat—follows the lead wire a sufficient distance to prevent sharp twists from breaking the wire. Laboratory testing indicates that operating life of the lead wire can be increased up to 10 times with this spring stress reliever.

Chromalox Electric Cartridge Heaters equipped with the spring stress reliever are available in ⅛", ¼", ⅜" and ½" diameters.

Let the Chromalox Sales Engineering staff solve your heating problems . . . electrically.

Write for your copy of Bulletin 850

for more specific information on Chromalox Electric Cartridge Heaters.

For information on the complete line of Chromalox Electric Heaters request Catalog 50.

Edwin L. Wiegand Company

7535 Thomas Boulevard • Pittsburgh 8, Pennsylvania

EDWIN L. WIEGAND COMPANY
7535 Thomas Boulevard, Pittsburgh 8, Pa.
I would like to have—
☐ a copy of Bulletin 850
☐ a copy of Catalog 50
☐ a Sales-Engineer contact me.

Name_____
Company_____
Street_____
City_____ Zone____ State_____

A-4457A

SEARCHLIGHT SECTION

(Classified Advertising)

BUSINESS OPPORTUNITIES — EQUIPMENT - USED or RESALE

UNDISPLAYED —RATES— DISPLAYED

$1.80 a line minimum 3 lines. To figure advance payment count 5 average words as a line.

BOX NUMBERS count as one line additional in undisplayed ads.

DISCOUNT of 10% if full payment is made in advance for four consecutive insertions of undisplayed ads (not including proposals).

The advertising rate is $16.85 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

AN ADVERTISING INCH is measured ⅞ inch vertically on one column, 3 columns—30 inches—to a page.

EQUIPMENT WANTED or FOR SALE ADVERTISEMENTS acceptable only in Displayed Style.

Send NEW ADVERTISEMENTS to N. Y. Office, 330 W. 42nd St., N. Y. 36, N. Y. for March issue closing February 20th

• CENTRIFUGAL BLOWERS •

Continuous Duty—110 V.—A.C.—60 Cycles

BRAND NEW • TOP QUALITY • FULLY GUARANTEED

100 C.F.M. — 3" Diameter ROTOR Powered by shaded pole, 2 pole enclosed motor. Sturdy cast aluminum housing with attached flange on discharge. Approx. 3" inlet, 2"x2" outlet.
No. BL100 Al..... $8.95
Available in DC 115 V. $16.95

TWIN BLOWER —520 C.F.M.—5½" DIAMETER ROTORS

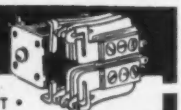
Redmond shaded pole four pole motor. 5" inlets and 3½"x3½" outlets. Discharge flanges shipped unmounted.
No. BL520R..... $22.50

ELECTRIC TRADING CO.

313-315 PE Canal St., New York 13, N. Y.

Air Equipment Experience Since 1926

RELAYS



MINIATURE AIRCRAFT • TELEPHONE TYPE • HERMETICALLY SEALED • SENSITROLS • STEPPING SWITCHES • GUARDIAN • KURMAN • ALLIED • SIGMA • LEACH *and many others.*

LARGEST STOCK OF RELAYS IN THE WORLD

PRODUCTION QUANTITIES IN STOCK

Send for our latest bulletin P

324 CANAL ST., N.Y.C., 13, N.Y. WAlker 5-9642

Universal general corp.

WANTED TO BUY
USED RECENT MODEL
TENSILE TESTING MACHINE

EITHER 60,000 100,000 or 200,000 LB. CAPACITY

W-8878, Product Engineering
330 W. 42 St., New York 36, N. Y.

PROFESSIONAL SERVICES

DESIGN ASSOCIATES
Tool Designing Available
Jigs, Fixtures, Progressive and Compound Dies
Layout and Detailing Service
2439 N. Charles St. Baltimore 18, Md.

GEORGE H. KENDALL
Consulting Mechanical Engineers
Methods Studies: Process or Product
Redesign Existing Products for Greater Profit,
Trouble Shooting Production, Design, Cost Problems,
Specialist Automatic Machinery, Process, Controls,
New Developments, Patent Studies, Investigations,
New Products & Process Engineering Studies
P. O. Box 3 (Est. 1923) Tel. Darien 5-1504
Noroton Heights 3 Offices Darien, Connecticut

WILLARD F. MASON
Consulting Electrical Engineer
Precision Electromechanical Designs
Specialist Slip Ring Assemblies—All Applications
Engineering Administration, Cost Systems
Product Development Programs
Manufacturing Facilities
180 Post Road, Darien, Conn. Oliver 5-9039

EMPLOYMENT OPPORTUNITIES

The Advertisements in this section include all employment opportunities—executive, management, technical, selling, office, skilled, manual, etc.

Positions Vacant
Positions Wanted
Part Time Work
Civil Service Opportunities
Selling Opportunities Wanted
Selling Opportunities Offered
Employment Agencies
Employment Services
Labor Bureaus

DISPLAYED —RATES— UNDISPLAYED

The advertising rate is $23.20 per inch for all advertising appearing on other than a contract basis. Contract rates quoted on request.

An advertising inch is measured ⅞" vertically on a column—3 columns—30 inches to a page.

Subject to Agency Commission.

$1.80 per line, minimum 3 lines. To figure advance payment count 5 average words as a line.

Box Numbers—counts as 1 line.

Discount of 10% if full payment is made in advance for 6 consecutive insertions.

Not subject to Agency Commission.

Send NEW ADS to PRODUCT ENGINEERING, 330 W. 42nd St., N. Y. for March issue closing February 20th

TWO KEY POSITIONS TO BE FILLED

A DESIGN ENGINEER *(HYDRAULIC)*

Mechanical Engineering Graduate with 8-10 years design experience including about 2-3 years experience in hydraulic circuits and rotary type pumps.

AND

A DESIGN ENGINEER *(GEARS)*

Mechanical Engineering Graduate with a minimum of 5 years design experience including gear analysis and general stress analysis.

Positions offer excellent opportunity for advancement with a well established and growing company. Hospitalization, life insurance and retirement income plan are financed by the Company. While this is not a military project, applicants must be U. S. Citizens.

Please send resume or telephone:

MR. T. R. SCHULZ
N.R.K. Mfg. & Engineering Co.
4601 W. Addison St.
Chicago 41, Ill.
Spring 7-2970

MACHINE DESIGNER

Man to take charge of and develop machine design section of medium size non-metal manufacturing company.

Work involves designing equipment for automating plant. Company currently undergoing extensive research and process development program. Ability to make free hand sketches and concise assembly drawings required. Submit complete resume of education, experience and salary requirement to:

Employment Manager,
P. O. Box 120, New Castle, Pennsylvania.

ASSISTANT TO VP.

Executive responsibilities in 800 man plant, making components & accessories for Aviation & Automotive industries.
This is a new plant in So. Calif. Co. pays agency fee & relocation expense. Starting salary $15,000. Replies will be kept in strictest confidence.

MONARCH PERSONNEL
28 E. Jackson Blvd. Chicago 4, Ill.

A message to the Career-Conscious Engineer:

Ready to change jobs?

Perhaps you are not receiving a salary commensurate with your work.

Perhaps you are dissatisfied with your rate of promotion.

Perhaps you do not have enough scope for your ability in your present job.

Or perhaps you simply want to move to Southern California.

We invite you to consider the California Division of Lockheed Aircraft Corporation as the place to re-establish your career. For these reasons:

Promotional Opportunities are excellent because there are so many supervisory positions to be filled with 46 major projects in progress at Lockheed and because Lockheed is in an expanding development and production program.

You have more scope to show what you can do because Lockheed projects range across virtually the entire spectrum of aeronautical endeavor. You are not limited to one type of work because Lockheed is so diversified in projects. Moreover, Lockheed encourages and welcomes personal initiative.

You may receive a substantial increase in pay because Lockheed is extremely liberal in direct salary and in extra employee benefits, which actually increase the value of your position by an average of 14%.

Positions are open at all levels for engineers in fields of: Aerodynamics – Design – Electronics, with emphasis on systems and antenna design – Flight Test Engineering, particularly in instrumentation – Math. Analysis – Operations Research – Structures – Thermodynamics.

Space prevents us from listing all the reasons we believe you will find significant. There are many others. But if our brief remarks make sense to you, write us and we can explore your opportunities at Lockheed through personal interview or phone. The brief resumé form below is simply for your convenience in contacting us.

TO ENGINEERS WHO LACK AIRCRAFT EXPERIENCE:

Aircraft experience is not necessary to join Lockheed. It's your engineering training and experience that count. Lockheed trains you for aircraft engineering – at full pay.

Lockheed AIRCRAFT CORPORATION

California Division BURBANK **California**

E. W. Des Lauriers, Dept. CJ-30-2
Lockheed Aircraft Corporation
Burbank, California

Name

Field of Engineering

Home address

Home phone

Where employed

College

ENGINEERS
Electronic *Mechanical*

There's room to... GROW AT MELPAR

Currently we seek men with experience in one or more of the following:

- Network Theory
- Systems Evaluations
- Microwave Technique
- UHF, VHF, or SHF Receivers
- Analog Computers
- Magnetic Tape Handling
- Digital Computers
- Radar and Countermeasures
- Packaging Electronic Equipment
- Pulse Circuitry
- Microwave Filters
- Flight Simulators
- Servomechanisms
- Subminiaturization
- Electro-Mechanical Design
- Small Mechanisms
- Quality Control and Test Engineers

More and more these days you hear top engineers talk about the many growth opportunities at Melpar. With an increasing number of significant electronic projects, an enlarged staff and facilities, Melpar provides many opportunities for professional growth and advancement. Our new laboratory is an engineer's dream come true; a building conceived by and constructed for the ENGINEER – 265,000 sq. ft. of complete engineering facilities.

We are located in Fairfax County of northern Virginia where housing is reasonable and plentiful—whether you desire a private home or an apartment. Although we are in a truly suburban atmosphere, we are only 10 miles from the nation's capital with all its recreational and social advantages. Here you and your family can grow in an environment to match your professional growth.

Send resume to Technical Personnel Representative,

melpar, inc.
A subsidiary of the Westinghouse Air Brake Co

3000 Arlington Blvd., Dept. PE-26 Falls Church, Va.
11 Galen Street, Watertown, Mass. • 99 First St., Cambridge, Mass.

EXPERIENCED
DESIGNERS - LAYOUT MEN

To Work At General Motors New Technical Center

For Experimental Automotive Work in Transmissions, Engines & Chassis.

The Engineering Staff is located in the suburbs of Detroit on an 820 acre site devoted to research and development work. Splendid opportunity for men looking toward the future. Ideal working conditions in well lighted, air conditioned office building. Fine recreational program with golf course adjacent to site. Opportunity to become a share holder in GM through a generous Stock Purchase Program. Also excellent health insurance, life insurance, and retirement plans.

State full particulars: Age, Experience, Salary Expected, Etc. *Send resume to:*

Personnel Dept.
Engineering Staff
General Motors Corporation
GM Technical Center
Detroit 2, Michigan

POSITION VACANT

Mechanical Engineer—with B.S. Degree—experience in production planning and design for production of mechanical equipment. Some knowledge of pumps and welded structures desirable. Plant location in North Jersey Industrial area. Send complete resume to PE, Box 1345, Miami 34, Fla.

CHIEF PRODUCT ENGINEER

To supervise design and development of automatic flow-control valves and devices for refrigeration, air conditioning, heating and general industrial applications. Should have at least 10 years' experience, and have some knowledge of electrical control mechanism.

Must be capable of supervising, leading and inspiring a force of from 12 to 15 engineers and designers in an organization looking forward to constant growth. BSME or BSEE degree or the equivalent in background and experience.

This is an important position with a well-known AAAA company, highly regarded as a leader in the control field. Midwest location in pleasant metropolitan community.

Excellent salary commensurate with background and experience.

Write
P-8898, Product Engineering
520 N. Michigan Ave., Chicago 11, Ill.

POSITIONS ALSO OPEN FOR DESIGN ENGINEERS—
LABORATORY ENGINEERS

YOUR ORGANIZATION

Is it complete?
Are you expanding it?
Making Replacements?

Naturally, you are anxious to secure the most suitable man or men available. You want men with the special training that will make them an asset to your organization. You can contact such men through an advertisement in the Employment Opportunities Section of PRODUCT ENGINEERING.

Classified Advertising Division
PRODUCT ENGINEERING
330 W. 42ND ST. NEW YORK 36, N. Y.

For RATES or INFORMATION
About Classified Advertising

Contact
The McGraw-Hill Office
Nearest you

ATLANTA, 3
1321 Rhodes-Haverty Bldg.
WAlnut 5778
W. LANIER

BOSTON, 16
350 Park Square
HUbbard 2-7160
P. McPHERSON

CHICAGO, 11
520 N. Michigan Ave.
MOhawk 4-5800
W. HIGGINS

CINCINNATI, 37
1915 Rockingham Ave.
W. H. GARDNER

CLEVELAND, 15
1510 Hanna Bldg.
SUperior 1-7000
C. J. LOUGHLIN

DALLAS, 2
Adolphus Tower
Main & Akard Sts.
G. L. JONES

DETROIT, 26
856 Penobscot Bldg.
WOodward 2-1793
L. SEEGAR

LOS ANGELES, 17
1125 W. 6th St.
MAdison 6-9351
H. L. KEELER

NEW YORK, 36
330 West 42 St.
LOngacre 4-3000
R. LAWLESS
W. SULLIVAN
D. COSTER

PHILADELPHIA, 3
17th & Sansom St.
Rittenhouse 6-0670
E. MINGLE
H. BOZARTH

ST. LOUIS, 8
3615 Olive St.
JEfferson 5-4867
W. HIGGENS

SAN FRANCISCO, 4
68 Post St.
DOuglas 2-4600
R. L. ALCORN

Executives and Engineers deserving higher salary

now can *completely, confidentially* make arrangements for better positions through our unique Job Improvement Service. We have close contact with leading manufacturing and research firms in all sections of the country.

Here's what you do. Send us your name, title, company and *home address*. We will forward to your home brief forms which you fill out and return. We compare your experience and desires with our file of specific job openings. You make the decision. No obligation to you, no cost whatsoever. Our clients pay us to find you. Find out what you're really worth—today. Write, phone or wire.

DECISION INC.

Management and
Recruitment Consultants
Oliver P. Bardes, President
452 First National Bank Building
Cincinnati 2, Ohio

ENGINEERS

The APPLIED PHYSICS LABORATORY of THE JOHNS HOPKINS UNIVERSITY offers an exceptional opportunity for professional advancement in a well-established Laboratory with a reputation for the encouragement of individual responsibility and self-direction.

Our program of

GUIDED MISSILE RESEARCH and DEVELOPMENT

provides such an opportunity for men qualified to design:

GUIDANCE, HOMING, AND CONTROL CIRCUITS
ANTENNAS
MICROWAVE COMPONENTS
COMPUTERS
THE EXTERNAL AERODYNAMICS OF MISSILES
RAMJETS
MISSILE STRUCTURES
LAUNCHERS
DATA-RECORDING AND PROCESSING EQUIPMENT

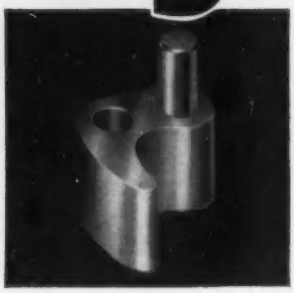
Please send your resume to Professional Staff Appointments

APPLIED PHYSICS LABORATORY
THE JOHNS HOPKINS UNIVERSITY
8641 Georgia Avenue
Silver Spring, Maryland

Dear Joe:
This is a quick note on the wire I just sent telling you to get that resume to Farnsworth - fast!
Now I know why the majority of engineers who come here for an interview never leave. The enthusiasm here - for the work - the people and the town - is really amazing. Maybe it's because of the close association with top-notch scientists and engineers who have contributed a lot of "firsts" in the field of electronics. Like our Phil Farnsworth, the inventor of electronic television and a real inspiration to all of us here. (I sound like an old timer, don't I?)
Fact is, Joe, that's the way they make you feel - like you belong. Here you will be heard - not just one of the herd. The whole set-up is so good, Joe, I wish you would tell all the other fellows about the opportunities here at Farnsworth for good men in R & D guidance and control, radar, microwaves, antennas, systems test equipment, countermeasures, transistor applications, closed circuit television etc.
Tell them to write to:
Don Dionne
Farnsworth Electronics Co. Fort Wayne, Ind.
(a division of International Telephone & Telegraph Corp.)
You'll be doing them and Farnsworth a big favor.
Sincerely
Jack

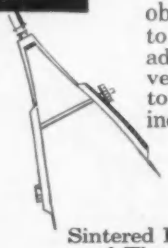
ANNOUNCING

. . . SINTERED POWDERED METAL BEARINGS and PARTS by Bunting!®



The newest facilities for the production of bearings and parts made of Sintered Powdered Metal are now offered to designer, engineer and machinery manufacturer by The Bunting Brass and Bronze Company.

Bunting resources, reputation and responsibility together with a complete new plant and modern equipment provide Sintered Powdered Metal products at a high point of quality and precision.



Bunting Engineering is available without cost or obligation to all who wish to use or explore the cost advantages that this versatile product brings to the mechanical industries.

Sintered Plain and Flange Bearings, Solid and Tubular Bars and Thrust Bearings are available from stock in a wide range of sizes. Quotations for special bearings or special parts will be sent promptly on receipt of prints.

Bunting®

BUSHINGS, BEARINGS, BARS AND SPECIAL PARTS OF CAST BRONZE AND POWDERED METAL

The Bunting Brass and Bronze Company • Toledo 1, Ohio • Branches in Principal Cities

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Smooth, durable, flexible joints in belting, aprons, tapes or ribbons are essential to the efficient operation of your machines. You can give your products new sales appeal and your customers important maintenance and operating savings by using Clipper joints.

Clipper belt lacing equipment produces secure, flexible joints in minutes, without injuring belting. It gives smooth joints that ride freely over conveyors or pulleys . . . that are flexible *both* ways of the belt. No other fastening method has *all* these advantages. Use Clipper belt hooks and lacers to put new dependability, serviceability and salability into your product.

WRITE FOR FREE SAMPLE

showing how Clipper fastens belts, aprons, tapes and ribbons into a smooth, flexible joint. Send a sample of your own material for a free lacing.

Ask your Industrial Distributor for Clipper Products

Clipper BELT LACER COMPANY

986 Front Ave., N. W., Grand Rapids 2, Michigan

DESIGNERS

if you have a dead-end job

send us your telephone number

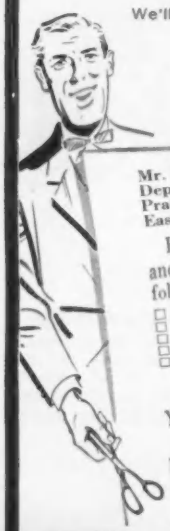
If you are stuck in a job without a future, it will pay you to investigate the wide variety of openings in our engineering department.

Here, the designer is a key man. He has a virtually unlimited opportunity to gain recognition and advancement. Outstanding men can, and frequently do, build sound, well-rewarded careers in a hurry.

In addition, there are other important advantages: new, higher salary ranges, liberal employee benefit programs, pleasant New England living, many others.

Fill in and mail the attached coupon immediately. We'll treat it confidentially; reply without delay. Your action now may be the first step toward a far better future for you and your family.

Be sure and include your telephone number. We may want to call you.



Mr. E. M. Peterson
Dept. 7, Design Employment
Pratt & Whitney Aircraft
East Hartford 8, Conn.

I would like to learn more about your openings for product and component designers. My experience has been in the following fields:

- ☐ Nuclear Design
- ☐ Compressors
- ☐ Turbines
- ☐ Structures
- ☐ Afterburners and Related Equipment
- ☐ Aerodynamics
- ☐ Hydraulics
- ☐ Gears
- ☐ Valves
- ☐ Heat Exchangers and Combustion Problems
- ☐ Bearings
- ☐ Piping
- ☐ Controls
- ☐ Test Equipment
- ☐ Test Rigs

Total years Mechanical Design experience .....

You can reach me at ..... (telephone) Most convenient

hours for receiving calls are between ..... and .....

NAME .....

ADDRESS .....

CITY ..... STATE .....

PRATT & WHITNEY AIRCRAFT
Division of United Aircraft Corporation
East Hartford 8, Connecticut

World's foremost designer and builder of aircraft engines

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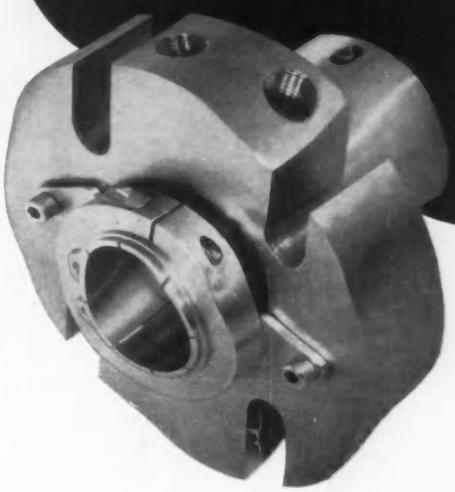

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SUMP TYPE (cutaway)

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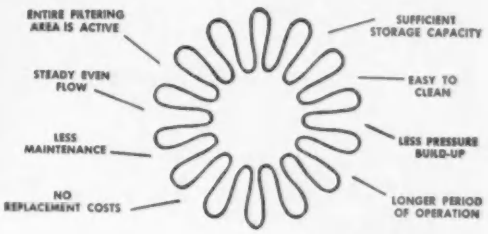

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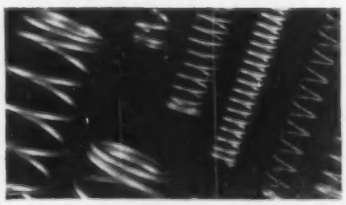

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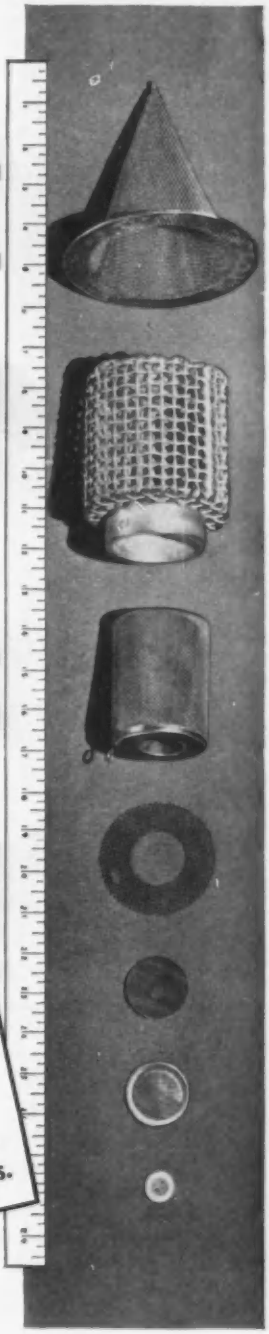

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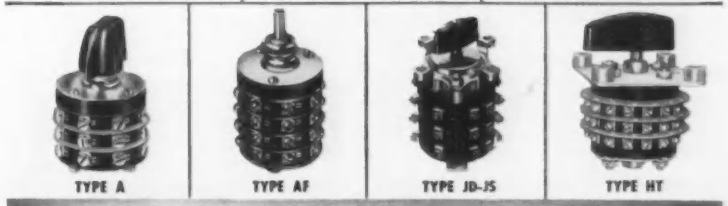

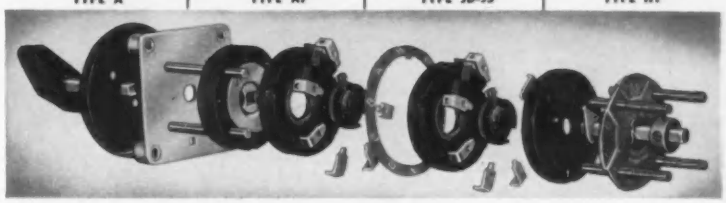

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- **TYPE P** — Multi-section, up to 4 positions, snap-action, rating 10 amperes — 125 volts a-c, 5 amperes — 125 volts d-c, 30, 60, 100, 200 amperes at 500 volts a-c, or 250 volts d-c. Can be assembled to meet Specification MIL-S-15291.
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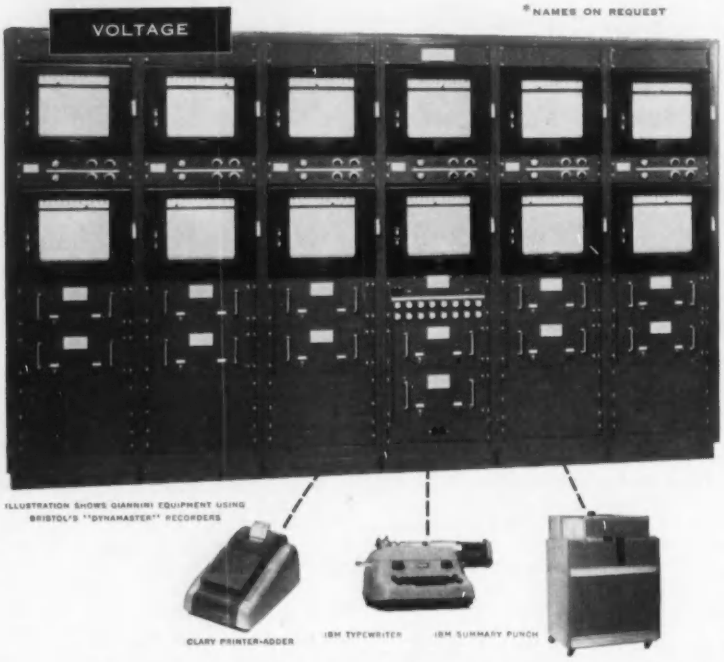

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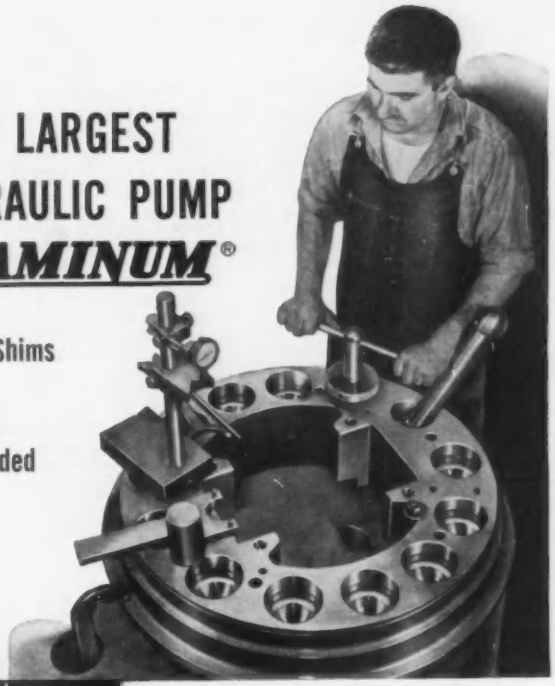

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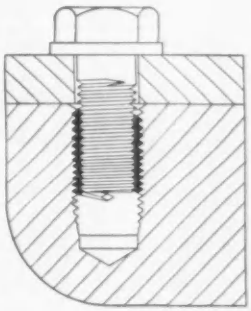

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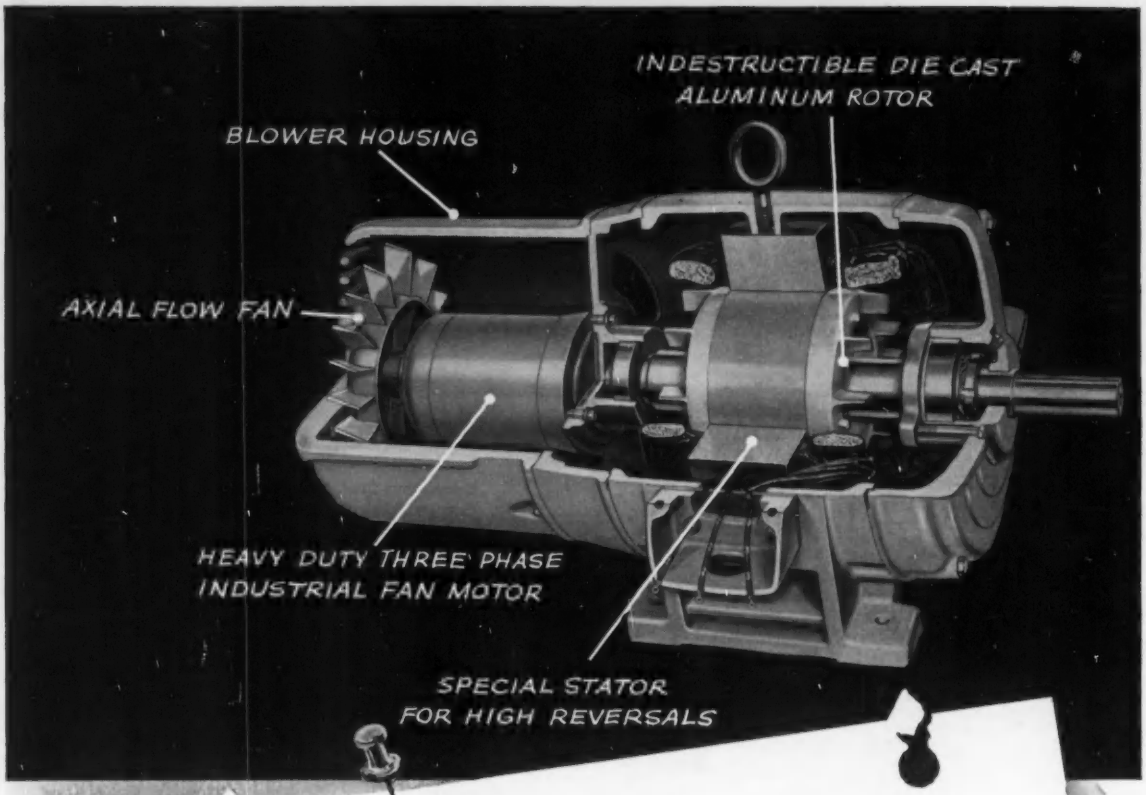
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Send for bulletin 1800 describing these new motors.

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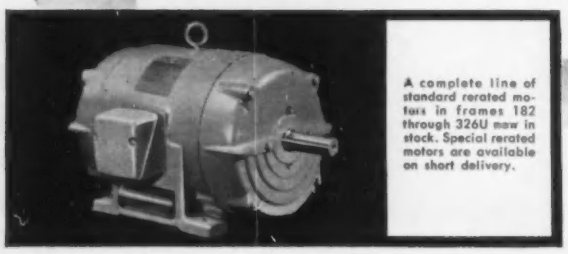

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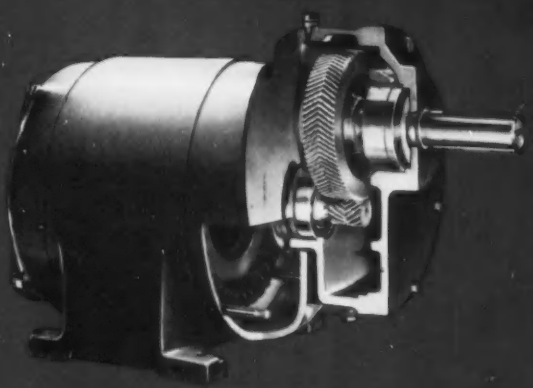

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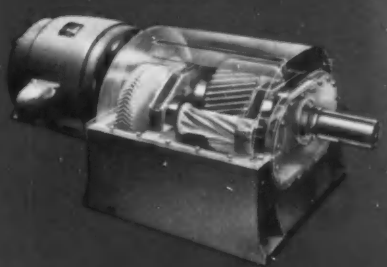

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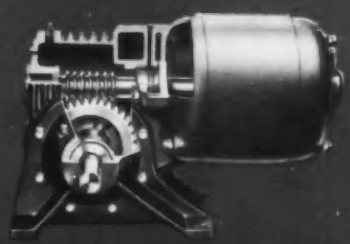

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